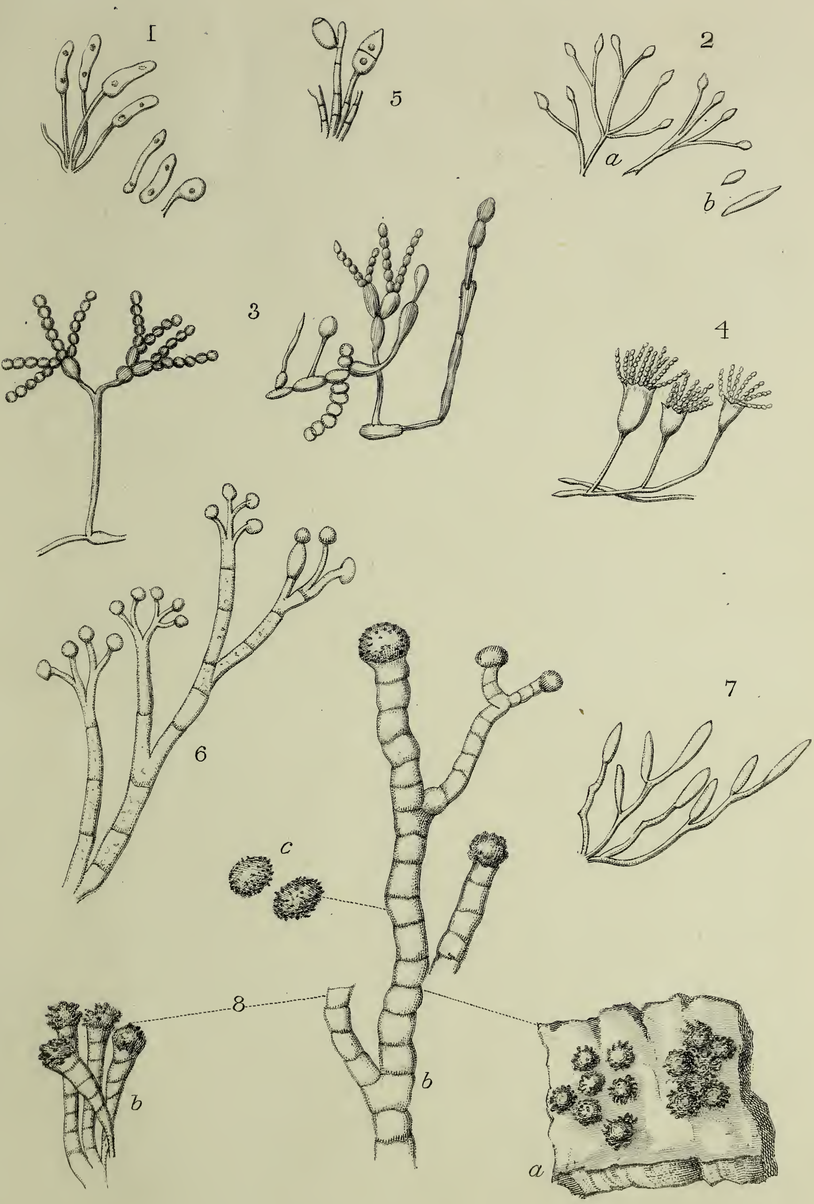

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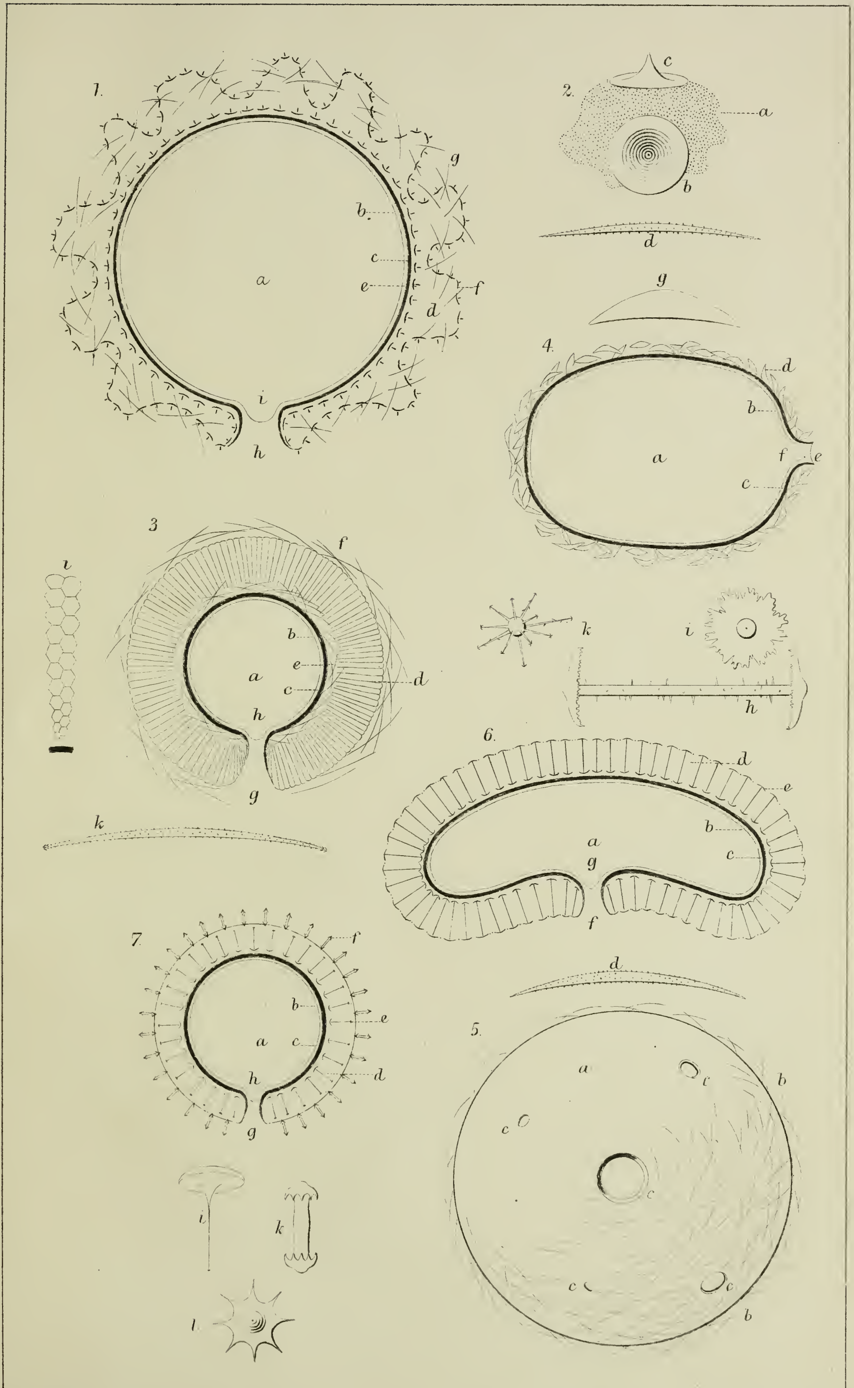

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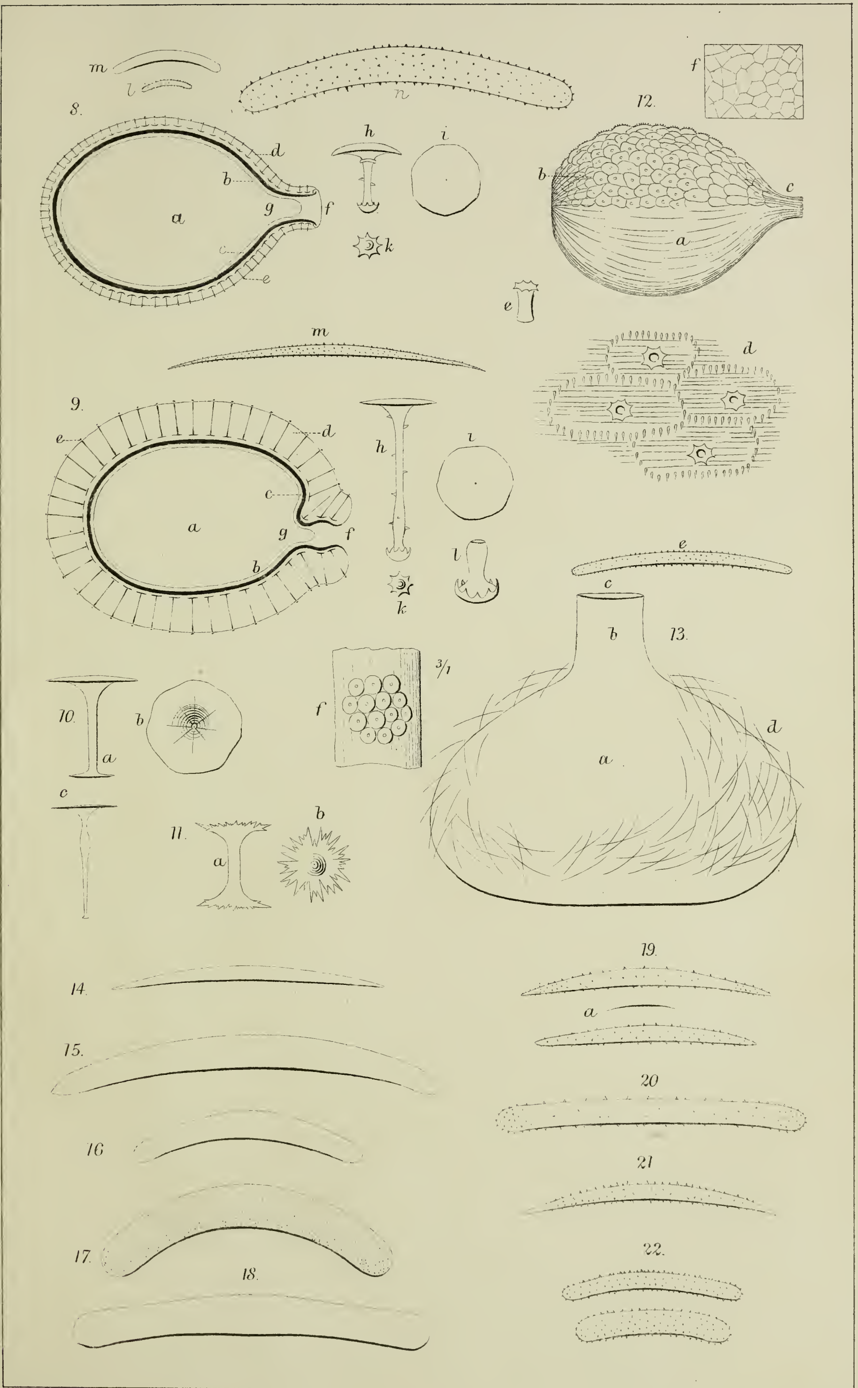

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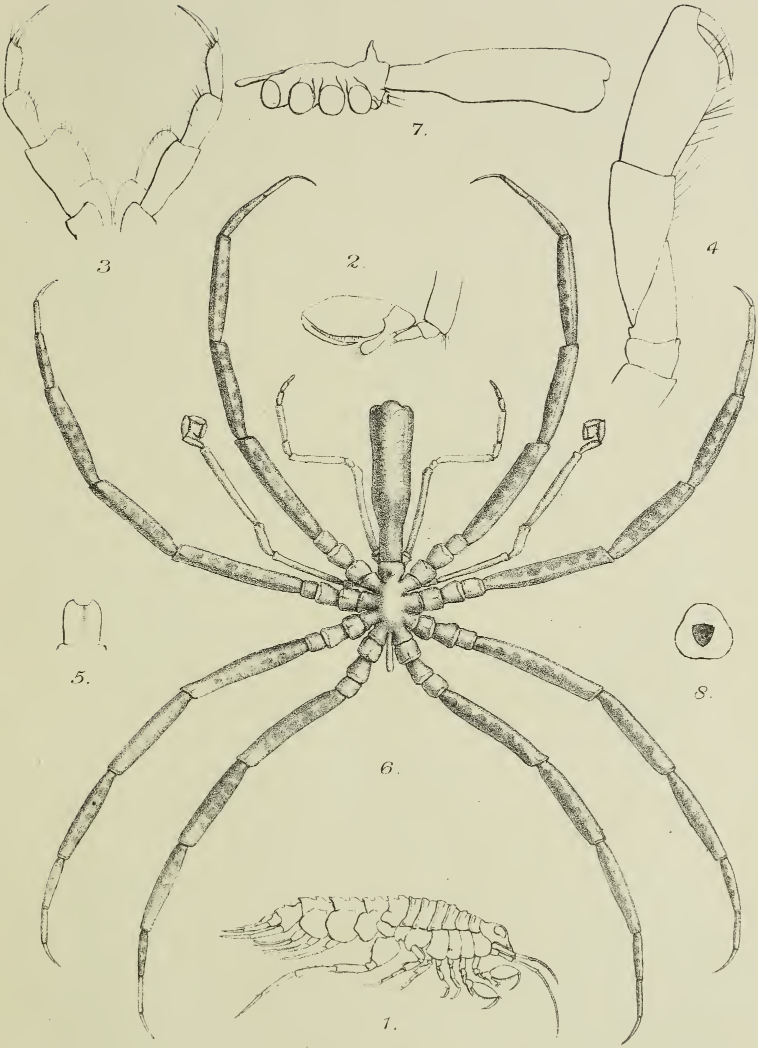

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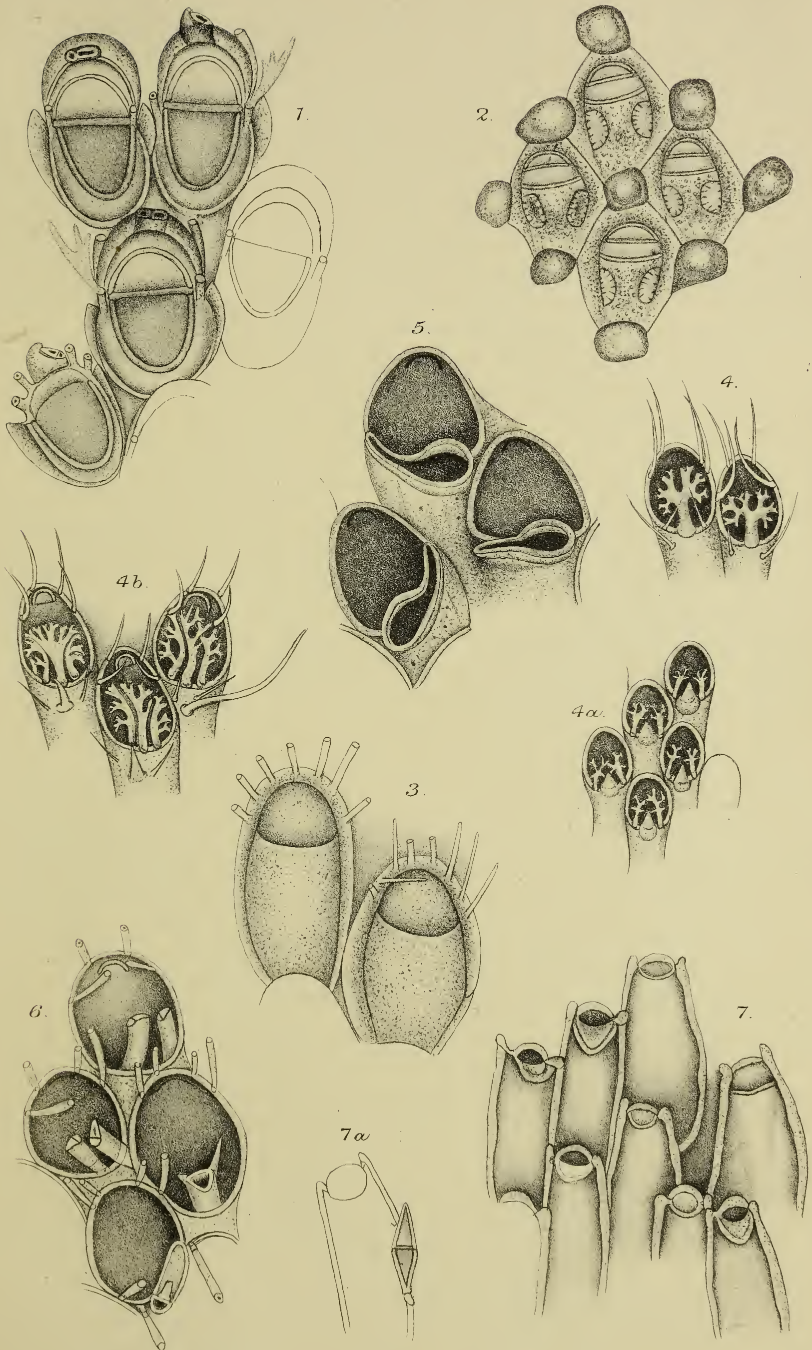

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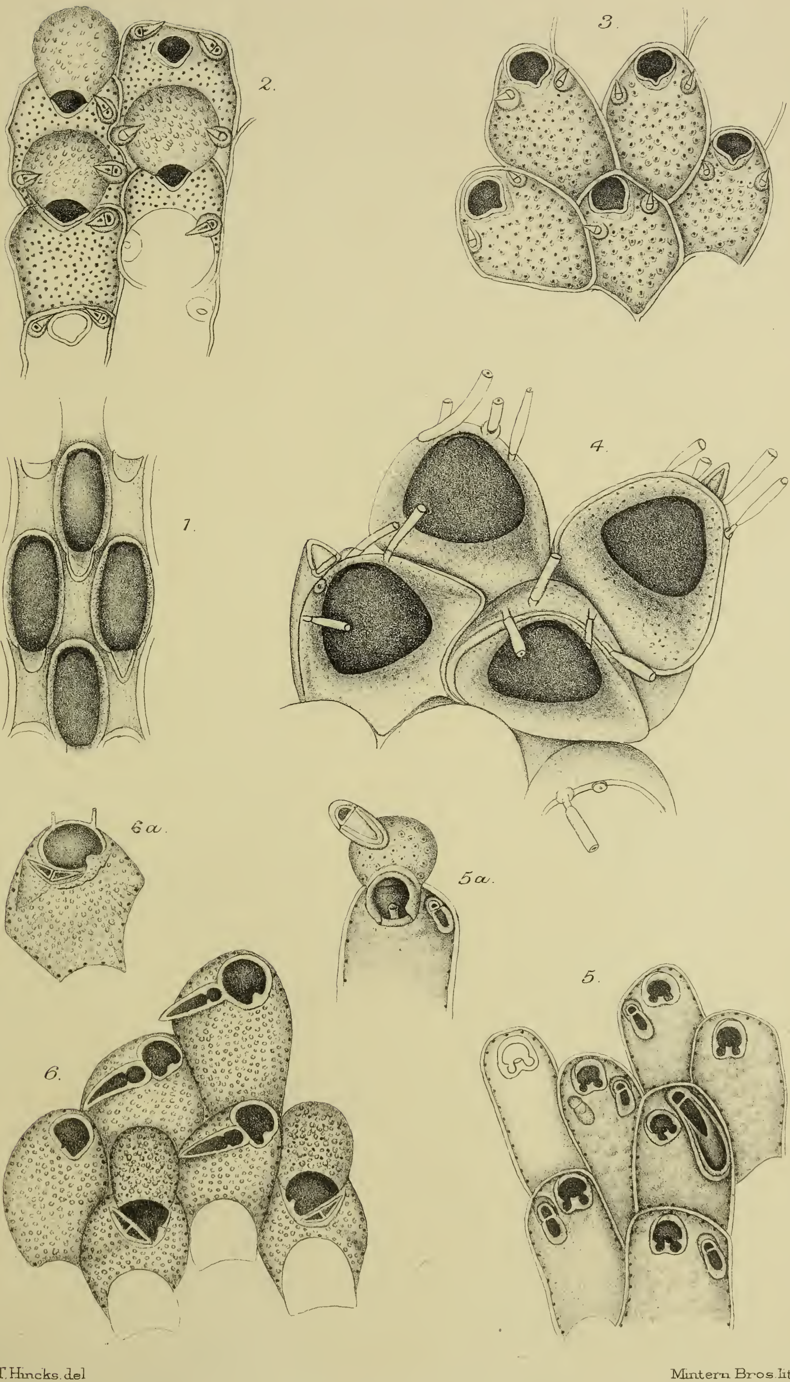

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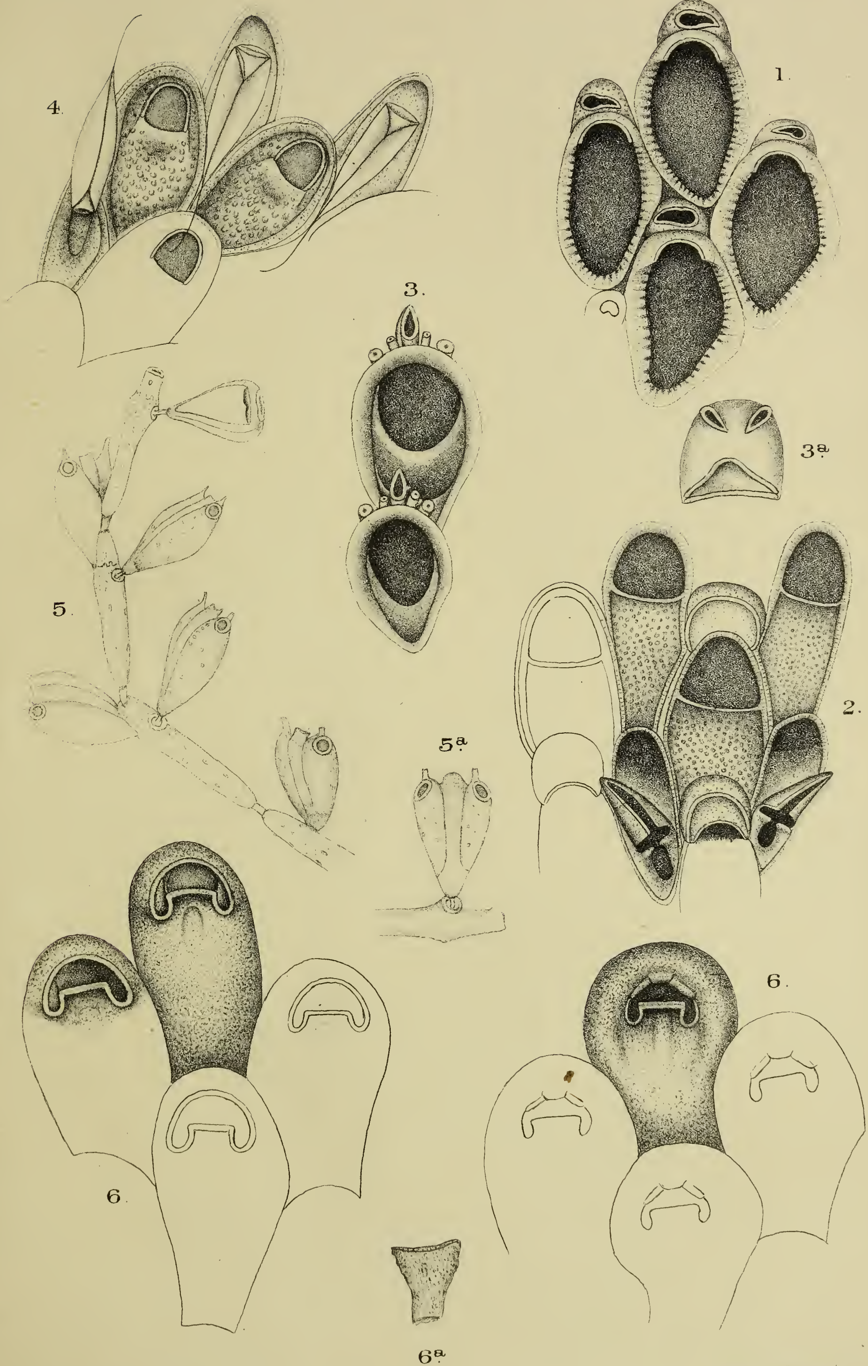

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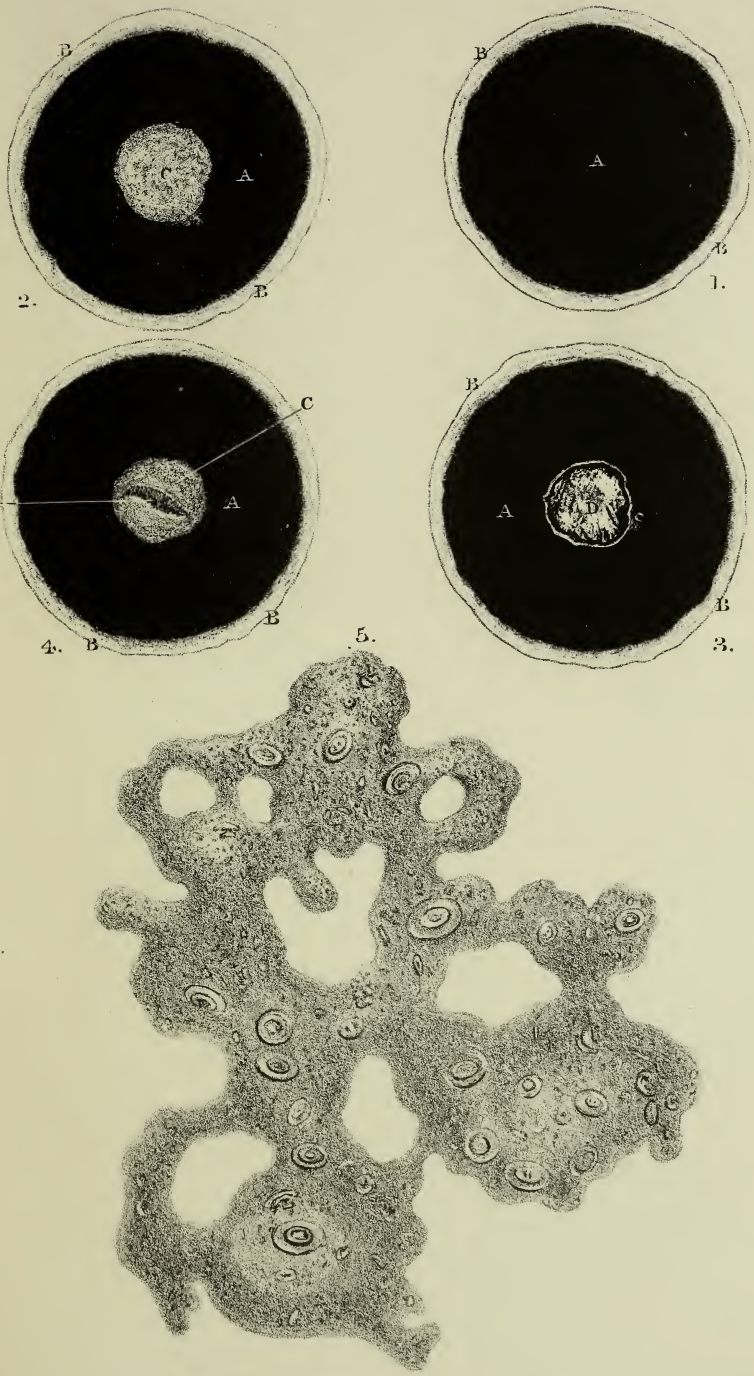

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gilla," instituted for the genus by Lamarck in 1816 (No. 5), has taken precedence of all the rest, whereby we now have *Spongilla fluviatilis* and *S. lacustris.*

It was not, however, until the improvements of the microscope ushered in an era of minuter observation that *Spongilla* was more particularly examined, when Dr. Grant (my kind friend and able teacher) published his "Observations" in 1826 (No. 6). After this, Meyen, in 1839, pointed out that the crust of the sphærula or seed-like body (statoblast) was composed of vertically placed spicula 1-250th to 1-200th of a millim. broad, at whose extremities, near the circumference, more or less toothed little disks are formed (Pl. VI. fig. 11, *a*, *b*), and further that, "besides the larger siliceous spicula within the substance of the sponge, there exist more delicate ones of 1-16th to 1-10th of a millim. long, having upon their surface little points which elongate as their age increases" (apud Johnston, No. 10, p. 154, footnote). Here

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21.—1866. Bowerbank, J. Monograph of the British Spongiadæ, vol. ii. pp. 339–344, *Spongilla fluviatilis* and *S. lacustris*; ib. vol. i. p. 262, spicula of the ovaries of *Spongilla*; pl. ix. figs. 201–227, pls. xxii. and xxiii. figs. 217–322 (figures of the "ovaries").

22.—1867. Gray, J. E. "Notes on the Arrangement of Sponges," Proc. Zool. Soc. London, May 9, p. 550, &c. (Potamospongia, classification of).

23.—1867. James-Clark, H. J. "*Spongiæ ciliatæ* as *Infusoria flagellata,*" Journ. Boston Soc. Nat. Hist. vol. i. pt. 3, pls. ix. and x.

24.—1868. Carter, H. J. "On a Variety of *Spongilla Meyeni* from the River Exe, Devonshire," Ann. & Mag. Nat. Hist. ser. 4, vol. i. p. 247.

25.—1870. Bowerbank, J. Monograph of the British Spongiadæ, vol. iii. pls. lix. and lx.

26.—1874. Carter, H. J. "On the Nature of the Seed-like Body of *Spongilla*, &c," Ann. & Mag. Nat. Hist. ser. 4, vol. xiv. p. 97.

27.—1875. Carter, H. J. "Notes Introductory to the Study and Classification of the Spongida," ibid. vol. xvi. p. 1, &c.: Potamospongida (pp. 187, 190, and 199).

28.—1877. Dybowski, W. "Ueber Spongillen der Ostsee-Provinzen," Sitzungsber d. Naturf. Gesellsch. zu Dorpat, Bd. iv. Heft 2, 1876, p. 258, Heft 3, 1877, p. 527.

29.—1878. Schulze, F. E. "Untersuchungen über den Bau und die Entwicklung der Spongien. Die Gattung *Halisarca,*" Zeitschrift f. wiss. Zoologie, Bd. xxviii.

30.—1879. Metschnikoff, E. "Spongiologische Studien," ibid. Bd. xxxii. p. 349, Taf. xx.–xxiii.

31.—1879. Carter, H. J. "On the Nutritive and Reproductive Processes of Sponges," Ann. & Mag. Nat. Hist. ser. 5, vol. iv. p. 374.

32.—1880. Dybowski, W. "Studien über die Spongien des Russischen Reiches mit besonderer Berücksichtigung der Spongien-Fauna des Baikal-Sees," Mém. Acad. Imp. d. Sc. de St. Pétersbourg, 7e série, t. xxvii. no. 6.

evidently the minute spicules with "toothed little disks" and "little points" respectively belonged to *Spongilla fluviatilis* and *S. lacustris*. Meyen also stated that the seed-like bodies or sphærulæ of *Spongilla* are "essentially distinct from the sporangia of Algæ, and are similar to what are denominated the *winter-eggs* of polypes" (No. 10, *l. c.*), which having endeavoured myself to illustrate and confirm in 1859 (No. 19), I finally adopted the term "statoblast" (No. 19, p. 340). Lastly, Mr. John Hogg, in 1840, demonstrated beyond question that these "seed-like bodies," or statoblasts, *germinated* in water, and thus reproduced the *Spongilla* (No. 9).

In 1842, Johnston published his work on the British Sponges (No. 10), from which the 'Monograph on the British Spongiadæ' of Dr. Bowerbank is chiefly compiled; and in Johnston's work an epitome of all that had been made known up to the time was given, not only of *Spongilla*, but of every other species of the British sponges that had been noticed, together with descriptions and illustrations from actual observation, not only of these but of many others which he added to them; so that this book is a *sine quâ non* to the student.

A few years after this, brings us to a period in which, besides the reproduction of *Spongilla* through the "seed-like body," one through *sexual elements* was also sought for and discovered. Thus, in 1856, Lieberkühn discovered and figured the ovum of *Spongilla*, together with the spermatozoa (Nos. 14, 15, and 16), which, as regards the ovum, Grant had done in the marine sponges in 1826 (Edin. New Phil. Journ. vol. ii. p. 133, pl. ii. figs. 27–29), and, as regards the spermatozoa, F. E. Schulze confirmed, in 1878, in the marine species *Halisarca lobularis* (No. 29). I take no account of my own observation of "zoosperms in *Spongilla*" in 1854 (No. 13), although the absence of the so-called "ear-like appendages" &c. in the figures of them &c. now seems to indicate that they were such, although in the interval I have doubted this, because the fact was not substantiated after the satisfactory manner in which it was subsequently demonstrated by the sagacious Lieberkühn.

Thus, then, in addition to the "seed-like body" in *Spongilla*, it was shown that the freshwater sponges could be propagated by elements of sexual reproduction like those of the marine sponges.

Shortly after this, my own observations (Nos. 17 and 18), coupled with those of James-Clark in 1867 (No. 23), established the "animality" of *Spongilla*, together with the form of the animal itself, for which, in 1872, I proposed the name "spongozoon" ('Annals,' vol. x. p. 45).

Finally Lieberkühn, observing what had been pointed out by Meyen in 1839, viz. that the seed-like body of *Spongilla* was partly composed of "little toothed" amphidisks, and that besides these there were others with "little points" or spines on their surface ("rauhen etwas gekrümmten"), made these the distinctive characters of *Spongilla fluviatilis* and *S. lacustris* respectively (No. 16, pp. 510, 511). This was confirmed by Bowerbank in 1863 (No. 20, p. 7, pl. xxxviii. fig. 1, *b*, *c*, and p. 24, *ib.* fig. 14, *c*); and good representations of these sponges were given by him in 1870 (No. 25, pls. lix. and lx.); but unfortunately the amphidisk or birotulate is omitted in the former, viz. that illustrating *S. fluviatilis*. Descriptions of the two species, as well as illustrations of the seed-like bodies and their spicules respectively, were also published by Dr. Bowerbank in 1866 (No. 21).

Thus the two species of *Spongilla*, hitherto doubtfully distinguished from ignorance of these more decided differences, were firmly established.

Having premised all the circumstances connected with the history of the freshwater sponge (*Spongilla*) that are necessary for the present occasion, we find that they are quite as much advanced physiologically as those of the marine species; and although the latter must ever be by far the most numerous, from the great extent of area producing them, yet, when we remember how few known species of *Spongilla* there are compared with the comparatively large area of freshwater which they may be inferred to inhabit, while the localities of the area in which they have been found are, with the exception of Europe, "few and far between," and as yet from Africa none at all have been described, it may also be inferred that hereafter a great many more species will be added to those with which we are at present acquainted, while the latter are already sufficiently numerous and diversified to render a classification of them desirable for further advancement.

This classification should, of course, be based on some peculiar and persistent characters which may yet admit of modified addition; and as we have seen that until Meyen had pointed out the form and presence of spicules in the seed-like body, no reliable distinction existed between *Spongilla fluviatilis* and *S. lacustris*, so we may assume that this may be anticipated throughout the family. And such is the fact; hence the classification which I am about to propose will be based chiefly on the spicules of the statoblast.

Up to the present time no species of marine sponge has been found to present a statoblast; while those of the freshwater sponge, although *specimens* are often without any (like the mycelium of "dry rot," *Merulius lachrymans*, which may destroy the woodwork of a whole mansion without putting forth its fructification in more than half a dozen places), might be assumed to be capable of producing them in every instance. So here we possess a sharp line of demarcation between the marine and freshwater sponges; for I have examined the type specimen (now in the British Museum) supposed by Dr. Bowerbank to show the existence of the seed-like body in his marine genus *Diplodemia* (No. 25, pl. lxx. fig. 12 and No. 21, vol. i. pl. xxiii. fig. 234, and vol. ii. p. 357), and find that this is nothing more than an insignificant portion of egg-bearing *Isodictya* adherent to the valve of a *Pecten*.

As already stated, Meyen considered the "seed-like body" of *Spongilla* to be equivalent to the "winter egg" of the polyp (Polyzoa); and, as before stated, I have endeavoured to confirm this view by parallel description and illustration (No. 19); while Prof. Allman having proposed the name "statoblast" for the winter egg of the freshwater Polyzoa (Monograph, Ray Society, 1856), must be my reason for calling the seed-like body the "statoblast" of *Spongilla*.

Describing the statoblast generally, it may be said to be in size about as big as a pin's head, varying in this respect, not only with the species but in the individual. For the most part it can be seen with the naked eye, and therefore does not differ much in size from the ova and embryos (swarmspores) of both the freshwater and marine sponges. In form it is more or less globular or elliptical (Pl. V. figs. 1 and 4), and of a whitish colour when fully developed, with a hole either lateral or terminal on the surface, generally at the bottom of an infundibular depression which leads to the interior (fig. 1, *h*, and 4, *e*, &c.). If we now make a vertical section through the hole or aperture of one of these bodies when dry (for this is the best time) with a sharp thin knife, we may observe that it consists of an internal, globular, axial cavity filled with a soft waxy substance of a yellowish colour, like that of dried yelk of egg (fig. 1, *a*, &c.); which substance, on microscopic examination, when swollen out in water, will be found to be composed of a great number of extremely thin, transparent, spherical sacs, filled respectively with minute germinal matter consisting of transparent germs or cellulæ of different sizes; the whole enclosed by a delicate, globular, transparent, investing membrane (fig. 1, *b*) slightly protruding at the aperture (fig. 1, *i*), and presenting a reticulated appearance like that of vegetable cell-structure when compressed *minus* any granules (fig. 12, *f*). (For further detail respecting these parts, see Nos. 12, 17, and 19.) Outside this follows a comparatively thick, translucent, homogeneous membrane, seemingly composed of chitine, whose amber colour being reflected through the "axial" substance gives the latter in the section a deeper tint than it is found to possess when separate; this will be called the "chitinous coat" (fig. 1, *c*). Then comes another kind of coat, composed, in two instances, of cell-structure, which is almost evident under a doublet (fig. 3, *d* and *i*), as will be seen hereafter, but in the rest of a white granular substance (fig. 2, *a*) that will presently be more particularly described, which can only be resolved into such by a very high compound power; and this will be called the "crust" (fig. 1, *d*); it appears to afford a floating property (like cork) to the statoblast, but varies very much in thickness, not only according to the amount of its development, but according to the species. The "crust," again, is charged with, or accompanied by, minute spicules of different forms, variously arranged according to the species, which will be found by-and-by, as before stated, to yield the chief characters of our classification (fig. 1, *g*, and fig. 2, *b*, *c*). At the "aperture," of course, these two coats are deficient, while the interior or chitinous one is prolonged into it by a tubular extension, generally in proportion to the thickness of the "crust" (fig. 1, *h*).

Meyen thought that the substance of the "crust" was composed of "carbonate of lime having a cellular structure" (No. 10, p. 154); but in no instance have I found it to effervesce with acids, while, on the contrary, after boiling it for some time in strong nitric acid it leaves a floccular residue, which may be assumed to be a colloid form of silica, unless it be undissolved tissue. As before stated, in some instances the cell-structure, being comparatively large, is perfectly evident, while in others it is only resolvable under a very high magnifying-power (at least 450 diameters), when it may be termed "microcell-structure," presenting under ordinary circumstances a white granular appearance, which, filling up the intervals between the spicules, imparts to the fully developed statoblast the light colour before mentioned. It floats in water, and is very much like "pith," without apparent cell-structure, is unaffected by liquor potassæ, and untinged by iodine, while before the blowpipe it burns off without leaving any perceptible residue. The floating-power of this substance is very considerable; for it keeps on the surface the whole of the internal contents, which swell out and sink to the bottom the moment they are liberated by section in water, while the remnants of the crust themselves continue to float with the greatest pertinacity. Still, although in most instances where the statoblast is fully developed it forms a thick coat, yet in others it can hardly be traced even under the microscope after the fully developed statoblast has been mounted in balsam; while it must not be forgotten that, as its development is progressive, it may be as *un*traceable at an early period in one as in the other.

Lastly, there is often a distinct layer of spicules which are more like those of the skeleton than those of the statoblast, but sufficiently differentiated by their peculiarities from both to show that they do not belong to either (Pl. VI. fig. 8, *l*, *n*); and these form a very distinct capsular covering to the statoblast, in which probably it was originally developed, and thus separated from its neighbours.

Generally the statoblasts are situated towards the base or first-formed portions of the *Spongilla*, either fixed to the object on which the sponge may be growing, or more or less scattered throughout its structure. The details of their development may be found in the papers to which I have last alluded; while, as this is also progressive, they often present themselves in a collapsed hemispherical state, without the crust, when the chitinous coat, being uncovered, gives them an amber colour, and thus their appearance generally is that of a different kind; but, as before stated, the statoblast when fully developed is, especially in the fresh state, globular, and, in proportion to the thickness of the crust, more or less white in colour. Yet there is a crustless spherical form, wherein too the aperture may be multiplicate—that is, double, triple, or even quintuple (Pl. V. fig. 5, *c c c c c*)—as first noticed in another species by Gervais (No. 7); with which also there appear to have been statoblasts that contained two or three others of the same kind presenting the same structure, the same composition, and the same yellowish colour (apud Johnston, No. 10, p. 154); so that, as before stated, the statoblast, although generally globular or elliptical, may have these forms modified in a variety of ways, as indeed may be seen in those which I have figured in Plates V. and VI.

Now, as the statoblast has so far been found in nearly all the freshwater sponges that have been described, and never in the marine ones, while the form of the skeleton-spicule is not only always acerate but almost always more or less alike in all, it follows from the latter being of little or no specific value that the statoblast, which is different in all, at least in the form of its spicules, must become the basis of the most reliable classification; and therefore I shall use its characters for what in this respect I may hereafter have to propose.

No attempt to classify the freshwater sponges had been made up to the publication of the late Dr. J. E. Gray's "Notes" in 1867 (No. 22, p. 491), when my dear old friend (alas! now only dear to memory) made them the seventh order in his "proposed" arrangement of the Spongida generally, under the terms "Potamospongia," family "Spongilladæ," with the following genera, viz.:—1. *Ephydatia*; 2. *Dosilia*; 3. *Metania*; 4. *Acalle*; 5. *Drulia*; 6. *Eunapius*; and 7. *Spongilla*; adding Dr. Bowerbank's *marine* species *Diplodemia* as an eighth genus—an incongruity arising from the misconception of Dr. Bowerbank to which I have already alluded. If Dr. Gray's "Notes" had been based on direct knowledge of the species of *Spongilla* themselves, and not on Dr. Bowerbank's "Monograph" (No. 20), it might have been unnecessary now to propose a different arrangement. It is enough to state of this "Monograph" that Dr. Bowerbank therein calls the statoblasts "ovaries," and in speaking of them in *Spongilla gregaria* (No. 20, p. 15) thus expresses himself—"The gregarious habit of these ovaries," &c.—to show the fallacies that might arise from such loose phraseology. But setting aside this and the like (for there is much to redeem it), I have had before me, in addition to the publications under reference, the actual specimens, while going through the late Dr. Bowerbank's collections for the British Museum (where they now are); and it has been from examination of these type specimens, together with my own from the island of Bombay, which were described, illustrated, and published long before Dr. Bowerbank's "Monograph of the Spongillidæ," that I have been induced to propose the following classification.

As may have been observed, in my "Notes introductory to the Study and Classification of the Spongida," in 1875 (No. 27), I found it necessary to make the freshwater sponges the fifth family of my sixth order of the Spongida generally, under the name of "Potamospongida," with a single group, at present named "Spongillina." Hence so far they will stand thus:—

Class SPONGIDA.

Order VI. **HOLORHAPHIDOTA.**

Char. Possessing a skeleton whose fibre is entirely composed of proper spicules bound together by a minimum of sarcode. Form of spicule variable.

Family 5. **Potamospongida.**

Freshwater Sponges.

Group 19. *Spongillina.*

Char. Bearing seed-like reproductive organs called "statoblasts."

Genera: 1. *Spongilla*; 2. *Meyenia*; 3. *Tubella*; 4. *Parmula*; 5. *Uruguaya.*

Spongilla.

Gen. char. Skeleton-spicule acerate, smooth, curved, fusiform, pointed, sometimes more or less spined or more or less inflated in the centre; sometimes accompanied by flesh-spicules. Statoblast globular, crust thick, thin, or absent altogether, accompanied by or charged with minute acerates (Pl. V. fig. 5, *b b*, *d*, &c.), smooth or spined according to the species, arranged tangentially.

* *Minute acerates smooth.*

1. *Spongilla Carteri*, Bk.

Spongilla Carteri, Bk., No. 20, p. 31, pl. xxxviii. fig. 20; provisionally *S. friabilis*, Lam., No. 12, p. 83, pl. iii. fig. 3.

Massive, sessile. Colour greenish or faint whitish yellow. Structure fragile, crumbling. Skeleton-spicule smooth, fusiform, curved, gradually † sharp-pointed. Statoblast globular; aperture infundibular; crust composed of pyramidal columns of dodecahedral or polyhedral cells, hexagonal in the section, regularly arranged one above another, in juxtaposition, perpendicularly to the outside of the chitinous coat on which they rest; surrounded by a layer of minute, fusiform, curved, and gradually sharp-pointed, smooth acerates (No. 19, pl. viii. figs. 1–3).

Loc. Bombay.

2. *Spongilla paupercula*, Bk.

Spongilla paupercula, Bk., No. 20, p. 32, pl. xxxviii. fig. 21.

Coating and branching. Skeleton-spicule curved, fusiform,

† "Gradually," in contradistinction to "abruptly" sharp-pointed (See Pl. VI. figs. 14 and 15 respectively).

sharp-pointed, smooth. Statoblast globular; spicules curved, fusiform, gradually sharp-pointed, smooth.

Loc. Water-pipes of Boston &c., U.S.

Obs. Mr. Thomas H. Higgin, F.L.S., of Liverpool, kindly sent me a specimen from the same locality, viz. the water-pipes of Boston, which, when examined, proved to have a similar skeleton-spicule, among which there are a number of minute, curved, fusiform, sharp-pointed acerates so like the flesh-spicules of *Spongilla lacustris* that, in the absence of statoblasts, I am led to consider it the same species; and if I am right, then the spicules of the statoblast should be spined, while those of *S. paupercula* were of the "same form as those of the skeleton, but not more than half their size;" so these would be more like statoblast-spicules of *S. Carteri*. My description of *S. paupercula*, Bk., is an abbreviated one of that given by Dr. Bowerbank himself (*l. c.*).

3. *Spongilla navicella*, Carter, n. sp.
(Pl. V. fig. 4, *a–g*.)

Sponge unknown. Skeleton-spicule curved, fusiform, smooth, gradually sharp-pointed. Statoblast adherent to the twig on which the sponge had grown; globoelliptical (fig. 4); aperture terminal, infundibular (fig. 4, *e*); no apparent crust; chitinous coat (fig. 4, *c*) encased with a dense layer of minute, stout, short, thick, more or less curved, fusiform, smooth acerates, variable in size, becoming so short internally (that is, where they are in immediate contact with the chitinous coat) as to be trapezoidal, or like a little boat or "cocked hat," according to the direction in which they are viewed; arranged tangentially, crossing each other (fig. 4, *d* and *g*).

Loc. River Amazons.

Obs. A few of the statoblasts were found on a small twig in company with *S. reticulata*, Bk., and *S. paupercula*, Bk., in the Bowerbank collection. They bear evidence of the existence in the river Amazons of a species of *Spongilla* whose entirety is as yet unknown; and it is very probable that a further search there would find many such.

** *Minute acerates spined.*

4. *Spongilla lacustris*, Linn.

Spongilla lacustris, Bk., No. 20, p. 24, pl. xxxviii. fig. 14; also No. 21, vol. ii. *l. c.* and vol. i. p. 342; also No. 25, pl. lx. and No. 16, pp. 510, 511.
S. lacustris auctt.

Branched; branches long, round, and sharp-pointed. Colour dark brown. Structure fibrous. Skeleton-spicule (Pl. VI. fig. 14) curved, fusiform, gradually sharp-pointed, smooth, sometimes more or less spiniferous. Flesh-spicule thin, curved, fusiform, gradually sharp-pointed, spined throughout. Statoblast when fully developed globular; aperture infundibular; crust composed of granular cell-structure, charged with more or less curved, minute, stout, fusiform, sharp-pointed acerates covered with stout recurved spines, arranged tangentially or centrifugally, like the lines of a so-called "engine-turned" watch-case.

Loc. England and Europe generally; North America; Asia, Lake Baikal (*Dybowski*).

5. *Spongilla alba*, Carter.

Spongilla alba, Carter, No. 12, p. 83, pl. iii. fig. 4; also No. 20, p. 25, pl. xxxviii. fig. 15.

Massive, spreading, subbranched. Structure fragile, tomentose. Colour whitish. Skeleton-spicule curved, fusiform, gradually sharp-pointed, smooth. Flesh-spicule thin, curved, fusiform, covered with spines, longest in the centre, where they are vertical and obtuse. Statoblast globular; aperture infundibular; crust thick, white, composed of granular cell-structure charged with minute, thick acerates, which are curved, cylindrical, round at the ends, covered with spines (especially about the extremities, where they are longest and much recurved), arranged tangentially, intercrossing each other like the lines of an engine-turned watch-case.

Loc. Bombay.

Obs. The spicules of the statoblast here, as well as in *Spongilla lacustris*, are considerably stouter, more curved, cylindrical, and more coarsely spined than the flesh-spicules of the sponge generally.

6. *Spongilla cerebellata*, Bk.

Spongilla cerebellata, No. 20, p. 27, pl. xxxviii. fig. 16.

This *Spongilla*, which appears to me to be only a variety of the foregoing species, differs from it chiefly in the absence of the "flesh-spicule," in addition to what Dr. Bowerbank has mentioned (*l. c.*).

Loc. Central India, Aurungabad.

7. *Spongilla multiforis* *, Carter, n. sp.
(Pl. V. fig. 5, *a–d.*)

Massive, incrusting. Colour dark brown. Structure fra-

* *multiforis*, with many doors or openings (in allusion to the plurality of the "apertures").

gile, fibrous, like that of *S. lacustris*. Skeleton-spicule curved, fusiform, gradually sharp-pointed, smooth, often inflated in the centre. Statoblast spherical (fig. 5); apertures in plurality (one to five) (fig. 5, *c c c c c*), on a level with the chitinous coat (fig. 5, *a*), as there is no apparent crust; surrounded by a layer of minute, curved, fusiform, sharp-pointed, spinous acerates, which are in contact with the chitinous coat, arranged tangentially (fig. 5, *b* and *d*).

Loc. Chiluk-weyuk Lake, British Columbia, lat. 49° 10′ N., long. 121° 22′ W.

Type specimen in the British Museum, presented by Dr. Lyall. Register no. 64. 8. 11. 1–10; running no. 239.

Obs. As the statoblasts, although very numerous, are all empty, it is probable that the germinal matter has passed out of them, and therefore that they are only the effete remains of this organ, although still covered by the statoblast-spicules, as represented in the illustration.

8. *Spongilla Lordii*, Bk.
(Pl. VI. fig. 13, *a–f*.)

Spongilla Lordii, Bk., No. 20, p. 28, pl. xxxviii. fig. 17.

Sessile, incrusting reeds (fig. 13, *f*); surface even. Structure fragile, crumbling. Colour light brown. Skeleton-spicule curved, fusiform, gradually sharp-pointed, smooth, often inflated in the centre. Statoblast hemispheroidal, flat bottle-shaped, forming a single layer in juxtaposition round the reed, underneath the sponge, with the aperture upwards (figs. 13 and 13 *f*); chitinous coat hemispheroidal (fig. 13, *a*); aperture prolonged from the summit by a short tubular extension (fig. 13, *b*, *c*); colour dark amber, followed by a thin granular crust charged with small curved, fusiform, spined acerates, round at the extremities, arranged tangentially (fig. 13, *d* and *e*).

Loc. Lake Osogoos, Cascade Mountains, British Columbia.

Type specimen in the British Museum. Register no. 68. 8. 17. 1–7; running no. 211. Presented by J. K. Lord, Esq.

9. *Spongilla nitens*, Carter, n. sp.
(Pl. V. fig. 3, *a–k*, and Pl. VI. fig. 18.)

Form of sponge unknown to me. Structure reticulate; fibre rigid, composed of bundles of spicules united by transparent colourless sarcode, which in the dried state gives it a hardness and vitreous appearance like that of *Spongilla corallioides*, Bk. Skeleton-spicule curved, cylindrical, smooth, sometimes very slightly inflated in the centre and at the extremities, which are round (Pl. VI. fig. 18). Statoblast globnlar (fig. 3); aperture infundibular (fig. 3, *g*); crust composed of pyramidal columns of dodecahedral or polygonal cells, hexagonal in the section, regularly arranged one above another, in juxtaposition (fig. 3, *d* and *i*), perpendicularly to the outside of the chitinous coat (fig. 3, *c*), on which, by the intervention of a layer of the statoblast-spicules (fig. 3, *e*), they rest, surrounded by a layer of minute, fusiform, curved acerates thickly spined, especially over the ends, where the spines are longest and recurved (fig. 3, *k*), arranged tangentially (fig. 3, *f*); the same kind of layer immediately round the chitinous coat, where the spicules appear to be intermixed with the lower cells of the crust, leaving the latter free between the two (fig. 3, *e*).

Loc. Unknown.

Obs. Of this species I can state nothing more than that a small fragment appeared in the Bowerbank collection labelled "*Spongilla*, new species, from the Jardin des Plantes." While it affords another instance of the crust of the statoblast being composed of apparently hexagonal cell-structure like that of *Spongilla Carteri*, the rigidity and vitreous appearance of the skeletal structure, if not the form of the spicule also, allies it to *Spongilla corallioides*, Bk., which will be seen hereafter to come from Uruguay. Finally, as this peculiar rigidity of the skeletal structure has in addition only been found in two species of *Spongilla* (viz. *S. Batesii* and *S. reticulata*, Bk.) from the river Amazons, it may be assumed that *S. nitens* also comes from South America. The presence of a layer of statoblast-spicules on the inside as well as on the outside of the crust will be seen by-and-by to occur also in the statoblast of *Parmula* (*Spongilla*) *Batesii*.

Meyenia*.

Gen. Char. Skeleton-spicule acerate, curved, fusiform, sharp-pointed, smooth, sometimes more or less spined, or more or less inflated in the centre. Statoblast globular or elliptical; crust composed of the granular structure mentioned, charged with birotulate spicules, *i. e.* spicular bodies which consist of a straight shaft terminated at each end by a disk, even or denticulated at the margin (Pl. V. fig. 6, *h*, &c.), arranged perpendicularly around the chitinous coat, so that one disk is applied to the latter, while the other forms part of the surface of the statoblast (fig. 6, *e*).

* "*Meyenia*," after Meyen, who first pointed out that the statoblast was partly composed of birotulate or amphidiscal spicules (*l. c.*).

* *Margin of disks even.*

1. *Meyenia erinaceus.*

Spongilla erinaceus, Ehr. apud Lieberkühn, No. 15, p. 509.

Of this species Lieberkühn says, "Zeichnet sich durch Nadeln aus, welche auf ihrer Oberfläche mit kleinen Stacheln versehen sind;" but the spinous character of this spicule *here* does not appear to be such a valuable character, in a specific point of view, as the disks of the birotulate spicule of the statoblast, which Lieberkühn describes in the following page to be without denticulation, and represents as umbonate with even circular margin and short shaft (No. 15, Taf. xv. fig. 31).

Loc. River Spree, Berlin.

Obs. This sponge appears otherwise, *i. e.* in structure and spiculation, to be like *Meyenia fluviatilis.* I do not know where Ehrenberg has described it.

2. *Meyenia Leidii.*

Spongilla Leidii, Bk., No. 20, p. 7, pl. xxxviii. fig. 2.

Thin, sessile, coating. Surface tuberculated, minutely hispid. Structure friable, crumbling. Skeleton-spicule curved, fusiform, abruptly sharp-pointed, sparsely spiniferous, becoming much smaller and more spined round the statoblasts. Statoblast globular, aperture infundibular; crust composed oi granular substance charged with birotulate spicules possessing very short shafts and evenly margined smooth umbonate disks, both of which have the margins more or less everted or turned outwards (that is, *from* the statoblast), arranged perpendicularly on the chitinous coat.

Loc. Schuylkill river, Pennsylvania.

3. *Meyenia gregaria.*

Spongilla gregaria, Bk., No. 20, p. 14, pl. xxxviii. fig. 7.

Sponge unknown. Skeleton-spicule cylindrical, stout and rather short. Form of statoblast not mentioned; crust charged with birotulate spicules composed of a short thick shaft terminated at each end by a simple umbonate disk with even circular margin, arranged perpendicularly to the chitinous coat. Spicules in the immediate neighbourhood of the statoblast cylindrical, slightly curved, and abundantly spiniferous, varying considerably in size.

Loc. River Amazons.

Obs. Having no specimen of this species to refer to, I got Mr. Stuart Ridley, F.L.S., of the British Museum, to examine the mounted specimens of *Spongilla gregaria* and *S. reticulata,* Bk., for me, since, although I have taken my diagnosis from Dr. Bowerbank's descriptions and illustrations (*l. c.*), still, as the skeletal spiculation of the former is almost precisely that of the latter, which covered the twig on which the statoblasts *alone* of *S. gregaria* were found, to the extent of "five inches," it seemed to be by no means impossible that the spiculation of the two species might have been confounded. Mr. Ridley's drawings are confirmatory of this possibility; and thus the skeletal spiculation given by Dr. Bowerbank to *S. gregaria* becomes nearly identical with that of the foregoing species, viz. *S. Leidii*, Bk.; but while the ends of the spicules are abruptly *pointed in the latter*, they are *equally round* in *S. reticulata* and those stated by Dr. Bowerbank to characterize the skeletal spicule of *S. gregaria.*

Undoubtedly we have the same sparsely spined skeleton-spicule becoming smaller and thickly spined in the immediate neighbourhood of the statoblasts in *S. Leidii*, *S. gregaria*, and *S. reticulata*, together with absolutely smooth skeleton-spicules in all three, if those assigned to *S. gregaria* by Dr. Bowerbank be the right ones. Thus the skeletal spicules and the spicules of the statoblasts in *S. Leidii* tending to the characters of those assigned to *S. gregaria*, in spite of the roundness of the ends of the skeletal spicules in the latter, seems to point out that the spinous element existed in both, and that generally they are closely allied; but, after all, it does not satisfy our doubt as to whether the round-ended spicules did not belong to *S. reticulata.* Further observation is required to decide this.

** *Margin of disks denticulated.*

4. *Meyenia fluviatilis.*

Spongilla fluviatilis, Bk., No. 20, p. 7, pl. xxxviii. fig. 1; also No. 21, vol. ii. p. 339; vol. i. pl. xxii. figs. 317–319; and No. 25, vol. iii. pl. lix.
Spongilla fluviatilis auctt.

Massive, lobate. Structure friable, crumbling. Colour light yellow-brown. Skeleton-spicule curved, fusiform, gradually sharp-pointed, smooth, often spined and often centrally inflated, Statoblast globular; aperture infundibular; crust thick, composed of the granular or microcell-substance, charged with birotulates whose umbonate disks are deeply and irregularly denticulated (Pl. VI. fig. 11, *a*, *b*), arranged parallel to each other and perpendicular to the chitinous coat.

Loc. England and Europe generally.

Obs. Here, as elsewhere, in proportion to the thickness of the crust is the length of the infundibular aperture, which is partly lined by a tubular extension of the chitinous coat.

Spongilla Meyeni, Carter.

Spongilla Meyeni, Carter, No. 12, p. 84; and No. 20, p. 10, pl. xxxviii. fig. 4.

Loc. Bombay.

Spongilla fluviatilis, var. *Parfitti*, Carter.

Spongilla fluviatilis, var. *Parfitti*, Carter, Ann. & Mag. Nat. Hist. 1868, vol. i. p. 247; and Bowerbank, 1870, No. 25, p. 298, pl. lxxxvi. figs. 5–14.

Loc. River Exe, Devonshire.

Obs. Having specimens of all three of these sponges now before me, I cannot help thinking that the occasional differences of spiculation in one may be seen in the other, and therefore that *S. Meyeni* and *S. fluviatilis*, var. *Parfitti* are mere varieties of *S. fluviatilis* = *Meyenia fluviatilis*, nobis. Of the two specimens of *S. fluviatilis*, var. *Parfitti*, that I have mounted, nearly all the skeleton-spicules in one are smooth, and nearly all those in the other are spiniferous, which shows what an admixture of these two kinds of spicules *may* exist in *Meyenia fluviatilis*. It is convenient here to allude to

Spongilla sceptrifera, Bk.

Spongilla sceptifera, Bk., No. 25, p. 300, pl. lxxxvi. figs. 15–17.

Loc. Reservoir, Exeter.

Obs. This pretended *new* species is no "new species" at all, but probably *S. fluviatilis*, as the statoblast would have proved if any had been present; for *S. fluviatilis* grows abundantly in the same locality, and the characteristic spicule represented by Dr. Bowerbank (*l. c.* fig. 17) is nothing more than a detached frustule of the diatom *Asterionella*, like *A. formosa* (Pritchard's Infusoria, ed. 1861, pl. iv. fig. 17), which, in its entirety (that is, with the frustules arranged in a radiated ring) as well as separated, abounds on the *surface* of the type specimen (which was kindly given to me by Mr. E. Parfitt, of Exeter), but *not in the interior*. It at once appeared to me that such a form of spicule could not belong to any species of *Spongilla*; and, indeed, I have never seen any thing identifiable with it either in the freshwater or marine sponges. Mr. Parfitt found the specimen, and sent part of it to Dr. Bowerbank, who immediately seized upon it as a new species of *Spongilla*.

5. *Meyenia Capewelli*.

Spongilla Capewelli, Bk., No. 20, p. 9, pl. xxxviii. fig. 3.

Massive, sessile. Surface even, lobular. Structure friable, crumbling. Skeleton-spicule curved, fusiform, abruptly sharp-pointed, smooth, sometimes inflated in the centre. Statoblast globular; aperture infundibular; crust thick, composed of granular microcell-substance charged with birotulate spicules consisting of a straight shaft somewhat inflated in the centre, terminated at each end by an umbonate disk of equal size, whose margin is irregularly crenulo-denticulate, and whose surface is granulated towards the circumference often in lines running towards the centre, mixed with faint radiating lines generally coming from that point, arranged perpendicularly, with one disk resting on the chitinous coat and the other forming part of the surface of the statoblast.

Loc. Lake Hindmarsh, Victoria, Australia, lat. 35° 30′ S., long. 141° 40′ E.

6. *Meyenia plumosa.* (Pl. V. fig. 6, *a-k.*)

Spongilla plumosa, Carter, No. 12, p. 85; No. 20, p. 11, pl. xxxviii. fig. 5.

Massive, lobate. Structure feathery, fibrous, friable. Colour greenish or light brown. Skeleton-spicule curved, fusiform, gradually sharp-pointed, smooth. Flesh-spicule stelliform, consisting of a variable number of arms of various lengths radiating from a large, smooth, globular body; arms spined throughout; spines longest at the ends, so as to present a capitate appearance, and recurved generally (fig. 6, *k*); the whole varying from a simple, spinous, linear spicule to the stellate form first mentioned, thus modified by the size and presence of the globular inflation and number of arms developed from the centre of the former; abundant in all parts of the structure, but especially in the neighbourhood of the statoblasts. Statoblast ellipsoidal (fig. 6); aperture lateral, infundibular (fig. 6, *f*); crust, which is thick and composed of granular microcell-substance (fig. 6, *d*), charged with birotulate spicules (fig. 6, *e*) consisting of a long, straight, sparsely spiniferous shaft whose spines are large, conical, and perpendicular, terminated at each end by an umbonate disk of equal size, whose margin is irregularly denticulated, with the processes more or less turned inwards (fig. 6, *h*, *i*), arranged perpendicularly, with one disk resting on the chitinous coat and the other forming part of the surface of the crust (fig. 6, *e*).

Loc. Bombay.

Obs. The variety in the minute spiculation generally of this species renders it perhaps the most beautiful in this respect that has yet been discovered.

7. *Meyenia Baileyi.*

Spongilla Baileyi, Bk., No. 20, p. 13, pl. xxxviii. fig. 6.

Coating, surface smooth. Structure friable, crumbling. Skeleton-spicule curved, subfusiform, gradually sharp-pointed, smooth. Flesh-spicule minute, curved, fusiform, gradually sharp-pointed, covered with erect obtuse spines throughout, extremely small towards the extremities, and extremely long and perpendicular about the centre of the shaft. Statoblast globular; aperture infundibular; crust, which is thick and composed of granular cell-substance, charged with birotulate spicules consisting of a long, straight, sparsely spiniferous shaft whose spines are large, irregular in length, conical and perpendicular, terminated at each end by an umbonate disk of equal size deeply but regularly denticulated, whose processes are claw-like and turned inwards, arranged perpendicularly, with one disk resting on the chitinous coat and the other forming part of the surface of the statoblast.

Loc. New York. In a stream on the Canterbury Road, West Point.

Obs. This seems to be the North-American representative of the Bombay species, viz. *Meyenia plumosa*, but with globular, not elliptical, statoblast.

8. *Meyenia anonyma*, Carter, n. sp.
(Pl. VI. fig. 12, *a–f.*)

Sponge unknown. Statoblast flask-shaped (fig. 12); aperture terminal (fig. 12, *c*); composed of a membranous coat striated longitudinally (fig. 12, *a*), supporting a reticulation (fig. 12, *b*) consisting of extremely minute, erect, conical processes with their sharp ends inwards, and presenting in the centre of each interstice, especially towards the fundus, a short, thick, somewhat hourglass-shaped spicule whose outer end is more or less denticulated, and whose inner one is inserted into the striated coat (fig. 12, *d*, *e*). Investing membrane of the germinal matter transparent, presenting the usual polygonal reticulation without granules, like compressed cell-structure (fig. 12, *f*).

Loc. River Amazons.

Obs. Of this statoblast, which is indicative of an undescribed species of *Spongilla*, I can state nothing more than that its presence appeared to me to be an accidental occurrence on the surface of another species which had grown over the surface of a leaf sent to me by Dr. Dickie.

Tubella*.

Gen. char. Skeleton-spicule curved, fusiform, sharp-pointed or rounded at the extremities, smooth or spined. Statoblast globular or elliptical; aperture lateral or terminal; crust composed of the granular microcell-substance mentioned, charged with inæquibirotulate spicules—that is, a little trumpet-shaped spicule having a straight shaft which is smooth, spined or inflated, or both, terminated by a large disk at one, and a small one or an umbonous, circular, marginally spined head at the other end (Pl. V. fig. 7, *i*); the former applied to the chitinous coat, and the latter forming part of the surface of the statoblast.

1. *Tubella paulula.* (Pl. VI. fig. 10, *a–c.*)

Spongilla paulula, Bk., No. 20, p. 15, pl. xxxviii. fig. 8.

Thin, incrusting. Surface even. Structure fragile, crumbling. Colour now brown. Skeleton-spicule curved, fusiform, abruptly sharp-pointed, spiniferous or smooth. Statoblast globular; aperture sunken, infundibular; crust composed of granular microcell-structure charged with two kinds of inæquibirotulates, one form of which is much stouter than the other, and consists of a straight shaft passing by trumpet-like expansion into the large disk, which often has radiating lines, and abruptly terminating in the other, which is only one fourth of the diameter of the former (Pl. VI. fig. 10, *a*, *b*); the other form similarly constructed, but more delicate, with the shaft inflated towards the large disk, and the smaller one much less in proportion than in the larger form (fig. 10, *c*); the forms not mixed but confined to their statoblasts respectively; arranged perpendicularly, with the large disk resting on the chitinous coat, and the smaller one forming part of the surface of the statoblast.

Obs. Although the skeleton-spicule in Dr. Bowerbank's illustration is smooth, it is stated in his diagnosis (p. 16, *l. c.*) to be "entirely spined," which is the case generally, but not always; so that the artist must have taken for the illustration one of the smooth ones.

2. *Tubella spinata*, Carter, n. sp. (Pl. VI. fig. 9, *a–m.*)

Thin, coating, spreading. Structure fragile, crumbling. Colour light brown. Skeleton-spicule curved, fusiform, gradually sharp-pointed, smooth or spiniferous. Flesh-spicule minute, curved, fusiform, thin, gradually sharp-pointed,

* *Tubella*, a little *straight* trumpet.

covered with perpendicular spines, which are longest about the centre (fig. 9, *m*). Statoblast elliptical, flask-shaped; aperture terminal (fig. 9, *f*); crust thick, composed of granular microcell-substance (fig. 9, *d*) charged with inæquibirotulate spicules (fig. 9, *e*) consisting of a straight shaft, inflated near the small end, and passing by trumpet-like expansion into the large disk, sparsely spined (fig. 9, *h*); disk circular, smooth, with even margin (fig. 9, *i*), small end consisting of a circular convex head, regularly denticulated on the margin with eight or more conical processes, which are slightly inclined towards the shaft (fig. 9, *k*, *l*); arranged perpendicularly, so that the disk rests on the chitinous coat and the head forms part of the surface of the statoblast (fig. 9, *e*).

Loc. River Amazons. On a leaf sent to me by Dr. Dickie in 1878.

3. *Tubella reticulata.* (Pl. VI. fig. 8 *a–n*, and fig. 16.)

Spongilla reticulata, Bk., No. 20, p. 17, pl. xxxviii. fig. 9.

Elliptical, or fusiform when growing round the immersed small branches of trees. Structure *extremely rigid*, reticulate, terminating in thorn-like processes on the surface. Colour light sea-green when growing in clear water. Skeleton-spicules curved or bent, cylindrical or subfusiform, rounded at the ends, absolutely smooth or sparsely spiniferous (Pl. VI. fig. 8, *m*, and fig. 16), becoming more so towards the statoblasts, where they are not more than half the size, thickly spined, and in this shape form a distinct capsular layer around each of those organs (fig. 8, *l*, *n*). Statoblast elliptical, ovoid (fig. 8); aperture terminal (fig. 8, *f*); crust composed of granular microcell-substance (fig. 8, *d*) charged with inæquibirotulate spicules (fig. 8, *e*) consisting of a straight shaft passing by trumpet-like expansion into the large disk, with two or more spines about the centre, and furnished with a ring-like inflation towards the disk (fig. 8, *h*); disk circular, smooth, with even margin, which is somewhat recurved (fig. 8, *i*), small end consisting of a circular umbonate head regularly denticulated on the margin with 6–8 conical processes, which are slightly inclined inwards or towards the shaft (fig. 8, *k*); arranged perpendicularly, so that the disk rests on the chitinous coat, and the head or small end forms part of the surface of the statoblast (fig. 8, *e*).

Loc. River Amazons.

Obs. The skeletal structure of this species, although of the same rigid nature and general character as that of *Parmula Batesii* and *P. Brownii*, to be hereafter mentioned, is more reticulated and not nearly so coarse as in the latter.

4. *Tubella recurvata.* (Pl. V. fig. 7, *a–l.*)

Spongilla recurvata, Bk., No. 20, p. 18, pl. xxxviii. fig. 10.

Sessile, coating. Surface even. Structure fragile, crumbling. Colour brownish. Skeleton-spicule curved, fusiform, abruptly sharp-pointed, smooth or spiniferous. Statoblast globular (Pl. V. fig. 7); aperture infundibular (fig. 7, *g*); crust thick, composed of granular microcell-substance (fig. 7, *d*), charged with inæquibirotulate spicules (fig. 7, *e*) consisting of a delicate, straight, smooth shaft passing by trumpet-like expansion into the large disk, which is circular, smooth, saucer-shaped, inverted, with even margin, curved towards the shaft, and abruptly terminating in the other, which is only one eighth of the diameter of the disk (fig. 7, *i*), arranged perpendicularly with the large disk resting on the chitinous coat, and the small one somewhat *within* the surface of the crust (fig. 7, *e*); surrounded by a capsule of short thick spicules (fig. 7, *f*), consisting of a straight smooth shaft, slightly inflated in the centre, and terminated at each end by an equal-sized head, which is prominently umbonate, with circular margin regularly divided into eight conical teeth slightly incurved (fig. 7, *k*, *l*), arranged perpendicularly around the statoblast, with one end free and the other adherent to the surface of the crust (fig. 7, *f*).

Loc. River Amazons.

Obs. This kind of capsular covering is, so far, unique, and renders the whole structure of the statoblast as remarkable as it is beautiful under microscopic observation.

Parmula*.

Gen. char. Globular or elliptical, fusiform when growing round the small immersed branches of trees. Structure coarsely reticulate, extremely hard and rigid, rising into thorn-like processes on the surface. Colour light green. Skeleton-spicule acerate, curved, fusiform, abruptly sharp-pointed, smooth. Statoblast globular, large, more or less tubercular on the surface; aperture infundibular; crust composed of granular microcell-substance (Pl. V. fig. 2, *a*), charged with and surrounded by minute, spinous, acerate spicules (fig. 1, *g*, and 2, *d*), limited by a layer of parmuliform spicules (fig. 2, *b*, *c*) both internally and externally, the former in contact with the chitinous coat (fig. 1, *e*), and the latter on the surface of the crust† (fig. 1, *f*).

* *Parmula*, a little round shield.

† As these characters are taken from the only species yet known, they may hereafter have to undergo alteration.

1. *Parmula Batesii.*

(Pl. V. fig. 1, *a–i*, and fig. 2, *a–c*, also Pl. VI. fig. 15.)

Spongilla Batesii, Bk., No. 20, p. 21, pl. xxxviii. fig. 12.

More or less globular when growing round the small immersed branches of trees one inch or more in thickness. Structure coarsely reticulate, extremely hard and rigid, rising into thorn-like processes on the surface. Colour light sea-green. Skeleton-spicule curved, fusiform, abruptly sharp-pointed, smooth (Pl. VI. fig. 15), forming, when bundled together with the hard transparent sarcode, the rigid structure above mentioned, charged throughout with statoblasts. Statoblast large, globular, more or less uniformly tuberculated (Pl. V. fig. 1). Aperture infundibular (fig. 1, *h*). Crust very thick, composed of granular microcell-structure of a white colour, which, growing out through the interstices of the reticular arrangement of skeleton-spicules, reduced in size, which form a capsular covering to the statoblast, gives it the tuberculated character mentioned (fig. 1, *d*), charged with and surrounded by minute, thin, curved, fusiform, gradually sharp-pointed, spinous acerates irregularly dispersed throughout its substance (fig. 1, *g*, and 2, *d*), limited, both inside and outside, by a layer of parmuliform spicules, the former in contact with the chitinous coat (fig. 1, *e*), and the latter on the free surface of the crust, giving it a light brown colour (fig. 1, *f*). Parmuliform spicule circular, flat, infundibuliform, terminating in a point, like a little round shield turned up at the margin, which is even (fig. 2, *b*, *c*), arranged both internally and externally in juxtaposition, more or less overlapping each other, with the funnel-shaped process *outwards* in both instances, so that the surface of the crust is covered with little points (fig. 1, *f*).

Loc. River Amazons.

Obs. The double layer of statoblast-spicules, viz. one on the inner and the other on the outer side of the crust, is seen also in *Spongilla nitens*.

2. *Parmula Brownii.*

Spongilla Brownii, Bk., No. 20, p. 19, pl. xxxviii. fig. 11.

Globular, four or more inches in diameter, appended to a small twig rather than embracing it. Structure and colour the same as in the foregoing species. Skeleton-spicules the same, but diminished to half their size round the statoblasts, to which they afford a distinct capsule. Statoblast globular; aperture slightly infundibular; crust thin, composed of microscopically minute spherical cells, irregularly agglomerated together, so as to produce small lacinuliform processes, which project into the interspaces between the capsular spicules; unaccompanied by the spinous spicule, which is present in the foregoing species, and without a continuous layer of the parmuliform spicule over the surface, but presenting one in contact with the chitinous coat, where it is overlain by an extremely thin development of the microcellular crust, from which the lacinuliform processes above mentioned are projected.

Loc. British Guiana (*Schomburgk*). British Museum, general collection. Running no. 527.

Obs. The most remarkable part about this species is the cell-structure of the crust, which is just a transition in size from that of *Spongilla Carteri* and *S. nitens* to the minute granular form of *Parmula Batesii* &c., thus showing that the latter is also composed of minute cells, which, as before stated, require a power of 450 diameters to be resolved. Thus with *Tubella reticulata* and *Parmula Batesii* we possess three of those species with extremely rigid reticulated structure which as yet have only been found in the river Amazons, but to which the provisional genus "*Uruguaya*," as will presently be seen, also appears to be allied.

Uruguaya, n. gen. prov.

1. *Uruguaya corallioides.* (Pl. VI. fig. 17.)

Spongilla corallioides, Bk., No. 20, p. 22, pl. xxxviii. fig. 13.

Irregularly digitate; rising into a polychotomous and anastomosing mass of cylindrical branches, which may attain several inches (7 or more) in all directions. Colour faint whitish yellow or dark leaden on the surface, internally white or colourless. Surface even, vitreous in appearance, extremely hard, smooth, and compact, interrupted by small raised vents more or less uniformly distributed at short and unequal distances from each other. Internal structure composed of short densely reticulated fibre, formed of the skeleton-spicules of the sponge in bundles firmly united together by colourless sarcode, which, together with the spicules, in a dried state simulates, from its hardness and vitreous appearance, an *entirely* silicified mass. Skeleton-spicule very robust, much curved, cylindrical, rounded at both ends, smooth or microspined, about six times longer than it is broad (Pl. VI. fig. 17). Statoblast unknown.

Loc. "Rapids" of the river Uruguay, above the town of Salto, Uruguay.

Obs. This is a most interesting species in almost every particular. 1st. Some of the specimens of it that have been sent to England are very large. 2nd. That sent by Mr. George Higgin to his brother, Mr. Thomas H. Higgin, F.L.S., of Liverpool, the former took from the "rapids" of the river Uruguay, above the town of Salto, "200 or 300 miles" from the sea in the delta of the Parana; in which "rapids" the amount of water is subject to such great alteration in quantity that, when Mr. Higgin found it, the stream was confined to the "cracks in the rock," while when he returned to the spot again it was "40 feet deep." The specimen sent to Liverpool is still adherent to the piece of rock on which it grew; and all the other specimens of the sponge that Mr. Higgin saw at this spot were of the same kind. 3rd. In none of the specimens sent to England has the statoblast been seen, or any other trace of reproductive organs, although the size of the specimens evidences full growth, and the circumstances connected with them, viz. their presence in a river subject to great alteration in the size of the stream, and at a great distance from salt water, supply all that is required for a genuine freshwater sponge. 4th. The characters of the sponge above given are unique, although the hardness and rigidity of the skeletal structure seems to find a kinship with that of *Tubella reticulata* and *Parmula Batesii* &c., from the river Amazons, as before intimated, if not also with *Spongilla nitens*, whose locality is at present unknown.

With reference to the "leaden" colour of the surface, it is worthy of remark that this is not only confined to the surface, fading off into the white structure of the interior a little below it, but in the *same* branch may abruptly meet the faint whitish-yellow colour which the whole sponge may present on other occasions. The cause of this diversity in colour must be explained by future observation.

Of the specimens of this sponge known to me, one is in the Museum of the Royal College of Surgeons, which Dr. Bowerbank states is labelled "near Salto Grande, above Paysandu," presented by Mr. W. Bragge (No. 20, p. 23); but when Dr. Bowerbank adds that this place is on a tributary of the upper part of the river Amazons, it is evidently a mistake; for Salto and Paysandu are on the river Uruguay. Another specimen is in the British Museum, labelled "Freshwater sponge from Paraguay. Presented by R. McAndrew. Register no. 72. 11. 13. 1; running no. 622." A third is in the Liverpool Free Museum, viz. that sent to his brother by Mr. George Higgin, to which I have alluded; and a fourth is part of a specimen sent by Dr. Garland of Dublin to the same museum, which differs from all the rest in being of a faint yellow-white colour *throughout*, with an accumulation of minute brown bodies here and there on the surface towards the base, which are the capsules of one or two undescribed species of the verticellate infusorian "*Freia*," that cannot be confounded with the statoblasts (for they would be large enough to be seen with the naked eye, and situated in the interior).

Fulfilling all the other characters of a freshwater sponge, I cannot help thinking that a specimen will be found sooner or later in which the presence of the statoblast will complete them. At the same time, if we are right in identifying the statoblast with the winter-egg of the freshwater Polyzoon, that flustraceous Indian species which I have long since described and illustrated under the name of *Hislopia lacustris* ('Annals,' 1858, vol. i. p. 169, pl. vii.) has not, to my knowledge, been found to possess them; so it is not impossible that this may be the case with *Uruguaya corallioides*, of which I therefore make "provisionally" a new genus. The specimens mentioned have been carefully examined by different people over and over again; but in no instance has a trace of a statoblast been found, with the exception of that noticed by Dr. Bowerbank (No. 20, p. 23), which, I think, admits of much doubt, not so much of the existence of the "fragment" as of its belonging to *Uruguaya corallioides*.

Observations.

Although my classification is chiefly based upon the form of the spicules of the statoblast, yet it is not to be assumed that I have included all the species of the Spongillina that have been discovered, but those only in which this means of classification has been obtained, as will be seen by the following short summary of Dr. W. Dybowski's elaborate account of freshwater sponges from Lake Baikal, in Central Asia (No. 32).

The specimens were obtained by his brother Dr. Benedict Dybowski and Herr W. Godleuski while in Siberia, and have been divided into four species, with their varieties respectively, under the generic name of "*Lubomirskia*," after Prince Wladislau Lubomirski, thus—*L. baicalensis*, Pallas, sp., *L. bacillifera*, n. sp., *L. papyracea*, n. sp., and *L. intermedia*, n. sp.; in all of which the statoblast (gemmula) was absent; so that, whatever arrangement is made of them hereafter, the present one must rest upon their general form and that of their skeleton-spicule respectively, which places them much in the same position as the two original species (viz. *S. fluviatilis* and *S. lacustris*) before the spicules of their statoblasts were discovered.

Lubomirskia baicalensis.

Lubomirskia baicalensis, Pallas (apud Dybowski, No. 32, p. 11, Taf. i. fig. 1), with four varieties, viz. *a*, *β*, *γ*, *δ*.

One learns from the figure of this species (*op. cit.* Taf. i. fig. 1), which is half the natural size, that it consisted of long digital processes, about 14 inches by ½ an inch in their greatest diameters, more or less uniformly inflated at short intervals (that is, bullate), but solid throughout. Structure elastic, but not crumbling between the fingers. Colour dark grey or olive-green. Skeleton-spicule curved, fusiform, gradually sharp-pointed, spiniferous generally, but especially towards the ends, particularly in the variety *γ*, where the rest of the shaft is smooth (Pl. VI. fig. 19).

Loc. Lake Baikal.

Largest skeleton-spicule 0·222 by 0·021 millim. "Parenchyma-spicule" (? early form of the foregoing) 0·159 by 0·006 millim., a smooth thin acerate (fig. 19, *a*).

Lubomirskia bacillifera.

Lubomirskia bacillifera, n. sp. (No. 32, p. 22, Taf. i. figs. 2, 4, 5, and 6, &c.), with three varieties, viz. *a*, *β*, *γ*.

Massive, more or less lobed. Structure much the same as that of the foregoing species, but finer and softer. Colour grass-green. Skeleton-spicule curved, cylindrical, sometimes fusiform (as in the variety *β*), round at the ends, and spiniferous generally, but more particularly over the ends, sometimes (as in the varieties) smooth over the rest or middle of the shaft (Pl. VI. fig. 20).

Loc. Lake Baikal.

Largest skeleton-spicule 0·270 by 0·024 millim. Parenchyma-spicule a small, thin, smooth acerate. No measurement.

Lubomirskia intermedia.

Lubomirskia intermedia, n. sp. (No. 32, p. 28, Taf. iv. fig. 3, A, spicule only), with one variety, viz. *a*.

Flat, spreading. Structure like that of *L. baicalensis*, but more tender. Colour yellowish or olive-green. Skeleton-spicule curved, fusiform, gradually sharp-pointed, spiniferous generally (Pl. VI. fig. 21).

Loc. Lake Baikal.

Largest skeleton-spicule 0·222 by 0·018 millim. Parenchyma-spicule a large smooth acerate. No measurement given.

Lubomirskia papyracea.

Lubomirskia papyracea, n. sp. (No. 32, p. 33, taf. i. fig. 7 &c.).

Papyraceous in thinness, with smooth shining surface. Structure very soft. Colour white. Skeleton-spicule thick (seven times longer than broad), curved, cylindrical, round at the ends, thickly spiniferous throughout (Pl. VI. fig. 22).

Loc. Lake Baikal.

Largest skeleton-spicule 0·144 by 0·018 millim. Parenchyma-spicule a very small smooth acerate.

Obs. The "parenchyma-spicule" appears to be the same in each of these species, and therefore is probably merely an early form of the skeleton-spicule, and not a "flesh-spicule," which it is hardly to be supposed would be the same in all four.

Observations.

Besides the new species of freshwater sponges in Lake Baikal, Dr. Dybowski mentions the occurrence of *Spongilla lacustris* in a small lake at its western end, called the "Pachabicha See," together with a new species, viz. *S. sibirica* (No. 32, p. 66), which is not described; also the occurrence of *Spongilla lacustris* in the Goktscha See in Transcaucasia, in the Dnieper, Minsk, Livonia, and about Warsaw and Charkow; also *Ephydatia* (*Spongilla*) *fluviatilis* in Livonia, Warsaw, and Charkow; besides *Trachyspongilla erinaceus* (No. 28 and No. 32, Taf. 4. fig. 13 *a*), *Spongilla erinaceus* (No. 32, p. 33), ? *Spongilla erinaceus*, Ehr.

Thus it is evident from what has been above stated that freshwater sponges have been found in many parts of Europe, in Asia, and in the two Americas; but, to my knowledge, no notice has been made public of their occurrence in Africa; still it may be fairly inferred that new species will be discovered there as well as elsewhere; and a yet further inference may be drawn, viz. that we are only on the threshold of our knowledge of the extent and varieties of the Potamospongida generally, so vast are the freshwater areas that have not been explored for this purpose.

Ehrenberg in his 'Mikrogeologie,' 1855, Taf. 1–12, represents many amphidisks (birotulates) which he found in "freshwater deposits" of various parts of the world, several of which are quite different in form from those with which we are acquainted.

Lastly, I would observe that, although I have endeavoured to make the above communication immediately useful, it is by no means intended to supply what can only be obtained by a careful perusal at leisure of all that has been written on the subject, especially that to which I have referred.

EXPLANATION OF THE PLATES.

N.B.—1. All the figures of the statoblasts are drawn to the same scale, viz. 1-24th to 1-1800th inch, in order that their constituent parts may appear under the same magnifying-power. They, however, are to a certain extent diagrammatic for the sake of clearness, inasmuch as all the coats are of course *in contact* naturally; the chitinous coat, which is represented by the *dark* line, is not quite so thick and the spicules are not quite so scanty as they are represented; but, generally speaking, the whole may be considered *relatively* magnified on the scale above mentioned.

2. All the "more magnified" parts or spicules are drawn to the scale of 1-12th to 1-6000th inch.

3. The skeleton-spicules, viz. figs. 14–18, are drawn to the scale of 1-12th to 1-1800th inch, and the rest, viz. 19–22, on much the same scale, having been traced off those done with Hartnack's no. 4, prism and objective (No. 32, p. 69).

4. Fig. 13, *f*, is only magnified three diameters.

5. It should be remembered that all sponge-measurements, both general and elementary, can only be considered approximative; for what is fixed upon as a standard at one time may be upset by the measurements of another, chiefly on account of the objects appearing under different degrees of development in different specimens. Still there is an average largest size and shape of the spicule which can easily be recognized: but this too is subject to differences; for it may be thick or thin, although *fully developed*, while the former is the shortest and the latter the longest. Thus varieties are numerous; but the great point is to give the average shape and size of the fully-developed object, and to avoid as much as possible the variations; for the latter confuse, while a very slight acquaintance with sponge-structure points out that their existence may be inferred in all cases.

Plate V.

***Fig.* 1.** *Parmula Batesii.* Perpendicular section of the statoblast through the aperture, showing:—*a*, cavity filled with germinal matter; *b*, coat enclosing the same; *c*, chitinous coat; *d*, crust; *e*, internal layer of parmuliform spicules; *f*, external layer of the same; *g*, minute spinous acerate spicules; *h*, aperture; *i*, nipple-like prolongation of *b*.

***Fig.* 2.** The same. More magnified view of fragment of crust bearing two parmuliform spicules: *a*, crust, to show granular appearance of microcellular structure; *b*, parmuliform spicule, end view; *c*, the same, lateral view; *d*, more magnified view of spinous acerate spicule.

***Fig.* 3.** *Spongilla nitens*, n. sp. Perpendicular section of the statoblast through the aperture: *a*, cavity filled with germinal matter; *b*, coat enclosing the same; *c*, chitinous coat; *d*, crust composed of columns of hexagonal cells in the section, in juxtaposition; *e*, inner layer of spinous acerates; *f*, external layer of the same; *g*, aperture; *h*, nipple-like prolongation of *b*; *i*, more magnified view of cell-structure of crust; *k*, the same of spinous acerate.

***Fig.* 4.** *S. navicella*, n. sp. Perpendicular section of the statoblast through the aperture: *a*, cavity filled with germinal matter; *b*, coat enclosing the same; *c*, chitinous coat; *d*, layer or capsule composed of minute navicelliform acerates (no appearance of crust-substance); *e*, aperture; *f*, nipple-like prolongation of *b*; *g*, more magnified view of navicelliform spicule.

Fig. 5. *S. multiforis,* n. sp. External view of entire statoblast: *a,* chitinous coat; *bb,* layer of minute spinous acerate spicules (crust almost obsolete); *c c c c c,* apertures; *d,* more magnified view of spinous acerate.

Fig. 6. *Meyenia plumosa.* Perpendicular section of the statoblast through the aperture: *a,* cavity filled with germinal matter; *b,* coat enclosing the same; *c,* chitinous coat; *d,* crust; *e,* birotulate spicules *in situ*; *f,* aperture; *g,* nipple-like prolongation of *b*; *h,* birotulate spicule, more magnified; *i,* disk, end view; *k,* stellate form of flesh-spicule.

Fig. 7. *Tubella recurvata.* Perpendicular section of the statoblast through the aperture: *a,* cavity filled with germinal matter; *b,* coat enclosing the same; *c,* chitinous coat; *d,* crust; *e,* tubelliform or trumpet-like spicules *in situ*; *f,* capsule of equal-ended denticapitate spicules *in situ*; *g,* aperture; *h,* nipple-like prolongation of *b*; *i,* more magnified view of tubelliform spicule; *k,* the same of equal-ended denticapitate spicule; *l,* still more magnified end view of head of same.

Plate VI.

Fig. 8. *Tubella reticulata.* Perpendicular section of the statoblast through the aperture: *a,* cavity filled with germinal matter; *b,* coat enclosing the same; *c,* chitinous coat; *d,* crust; *e,* trumpet-like spicules *in situ*; *f,* aperture; *g,* nipple-like prolongation of *b*; *h,* more magnified view of trumpet-like spicule; *i,* the same of large disk, end view; *k,* the same of small disk, end view; *l,* small spinous skeleton-spicule forming a capsular layer to the statoblast; *m,* skeleton-spicule smooth or sparsely spined; *n,* more magnified view of *l.*

Fig. 9. *T. spinata,* n. sp. Perpendicular section of statoblast through the aperture: *a,* cavity filled with germinal matter; *b,* coat enclosing the same; *c,* chitinous coat; *d,* crust; *e,* trumpet-shaped spicules *in situ*; *f,* aperture; *g,* nipple-like prolongation of *b*; *h,* more magnified view of trumpet-shaped spicule with spinous shaft; *i,* large disk; *k,* small disk, denticulated, end view; *l,* the same, still more magnified, lateral view; *m,* flesh-spicule, spinous acerate.

Fig. 10. *T. paulula*: *a,* trumpet-shaped spicule, lateral view; *b,* large disk, end view; *c,* another form of the trumpet-like spicule. Scale 1-12th to 1-6000th inch.

Fig. 11. *Meyenia fluviatilis*: *a,* birotulate spicule, lateral view; *b,* denticulated disk, end view. Same scale.

Fig. 12. *Tubella anonyma,* n. sp. External view of statoblast of unknown sponge: *a,* striated coat; *b,* reticulated structure resting on the same; *c,* aperture; *d,* reticulated structure, more magnified, to show that it is composed of minute, erect, conical bodies in relief on the striated coat, having a spicule in the middle of the interstice; *e,* more magnified lateral view of spicule; *f,* fragment of coat of germinal matter, showing polygonal reticulation.

Fig. 13. *Spongilla Lordii.* Lateral view of entire statoblast: *a,* body or chitinous coat; *b,* neck, ending in *c,* aperture; *d,* coating of acerate spicules; *e,* more magnified view of spicule; *f,* group of statoblasts *in situ,* magnified three diameters.

Fig. 14. *S. lacustris.* Skeleton-spicule, to show the "gradually-pointed" form.

Fig. 15. *Parmula Batesii.* Skeleton-spicule, to show the "abruptly-pointed" form.
Fig. 16. *Tubella reticulata.* Skeleton-spicule, to show "rounded end."
Fig. 17. *Uruguaya corallioides.* Skeleton-spicule, to show micropunctation and "rounded" ends.
Fig. 18. *Spongilla nitens.* Skeleton-spicule, to compare with foregoing form.

Characteristic skeleton-spicules of freshwater sponges from Lake Baikal, after Dr. W. Dybowski; traced off the figures in Taf. iv. (No. 32), drawn with Hartnack's prism and no. 4 objective.

Fig. 19. *Lubomirskia baicalensis,* Pallas: *a,* "parenchyma-spicule," after Dybowski.
Fig. 20. *L. bacillifera,* n. sp.
Fig. 21. *L. intermedia,* n. sp.
Fig. 22. *L. papyracea,* n. sp., two forms.

X.—*Spolia Atlantica: Contributions to the Knowledge of the Changes of Form in Fishes during their Growth and Development, especially in the Pelagic Fishes of the Atlantic.* By Dr. C. F. Lütken.

[Continued from p. 14.]

8. Brama, Taractes, Pterycombus, Pteraclis.

With regard to *Brama,* it is to be remarked, in the first place, that it has been ascertained that *B. Raji* is not an almost exclusively Mediterranean species, but a bathyphilous and very cosmopolitan species, which is spread from the Färöes to the Cape, and represented at Chili, New Zealand, and Japan by very nearly allied, if not identical forms (*B. japonica,* Hilg., appears to be a distinct species), but has not yet been found among the Antilles or on the eastern coast of America. Leaving out of consideration some young forms (*B. Orcini, B. Dussumieri*) which cannot pretend to the rank of distinct species, a series of species from the Antilles, Madeira, &c. have subsequently been described, some with smooth scales, others, as in *Pteraclis* and *Pterycombus,* with a large spine upon the anterior margin of the visible part of each scale, and a corresponding notch in the posterior margin of the immediately preceding scale. It is a singular thing that it has not hitherto been observed that *B. Raji,* when young but yet about half-grown (290 millims.), has the scales armed with the same spines, which do not disappear until the fish approaches its full development. We are therefore not justified in forming a separate genus (*Taractes*) for the species of *Brama* with spines, nor in determining the young individuals furnished with spines (*Taractes asper, Brama Orcini* and

Dussumieri) as the young of species which retain the spinous character of the scales all their lives; for they may just as well belong to species which, like *B. Raji*, become completely smooth as they advance in age. The small *Bramæ* with spines, from 11–47 millims. long, that I have examined, which in general agree with the young forms above mentioned and formerly described, present no peculiarity which prevents our referring them to *B. Raji*; and consequently we may very well provisionally range these nominal species among the synonyms of the type species in question. It is probable, however, that the young individuals belonging to the different species of *Brama* will closely resemble one another, and be extremely difficult to distinguish; in those which I have at my disposal, some of which (the largest) were found in the stomach of large voracious fishes, and others (the smaller ones) fished at the surface of the Atlantic, I have been able to recognize only the elements of a single continuous series, and not the representatives of several species. One of the oldest and one of the youngest individuals of this series referred to *B. Raji* are represented in pl. iv. (of the Danish memoir); and I refer the reader for their differences and for their comparison with the adult fish to figs. 1 and 2.

With the young *Bramæ* which we have just been discussing there was also a *Pterycombus*, perhaps a young *P. brama*, an arctic species inhabiting deep water, hitherto known only from specimens derived from the coasts of Finmark and Norway; this specific determination, if correct, will furnish a fresh proof of the conformity presented in general by the faunas of great depths in the tropical and arctic seas. In the stomach of the same albacore which contained these interesting young Bramidæ there was also a young fish belonging to the arctic genus *Himantolophus*, perhaps *H. Reinhardti*. Fig. 4, pl. iv. (of the Danish memoir), placed near that of the adult *Brama*, will elucidate the very considerable changes that the young *Pterycombi* undergo during their growth and development.

A pelagic genus allied to *Brama* and *Pterycombus* is the genus *Pteraclis*, the still little-known species of which perhaps need to undergo some reduction. Our sailors have also found it in the stomachs of albacores; and they have moreover captured in the nets very small examples of 7–15 millims. long. Their physiognomy greatly resembles that of the young *Bramæ* and *Pterycombi*; and they differ as much as these and the young dorados from fully developed fish. The body is short, thick, and pyriform; the scales are high and hexagonal, each armed with a spine directed backward; the præoperculum is very spinous; the dorsal and anal are low and almost completely retractile within their scaly sheaths; as in the young *Coryphænæ* and *Pterycombi*, the dorsal does not commence so far forward as at a later period, and it is placed further back in proportion as the fish is younger; the ventrals are composed of a few very fine rays &c.

9. NAUCRATES, NAUCLERUS, and XYSTROPHORUS; NOMEUS, PORTHMEUS, LICHIA, and CHORINEMUS; PAROPSIS.

Mr. Gill and myself, some years ago, showed that the *Naucleri* are young forms of *Naucrates*; and the synonyms of the celebrated pilotfish (*N. ductor*) have consequently been augmented by the other probably merely nominal species of *Naucrates*, by all those of the genus *Nauclerus*, and by two species referred to the genus *Seriola*. But it has not hitherto been noticed that *Xystrophorus*, Rich., is nothing but the youngest form of *Naucrates*; moreover, among the first stages of *Seriola* there are also some which present, in part, the characters of *Xystrophorus*. The very young *Naucrates* are among the small fishes which are often met with among the arms, tentacles, &c. of the *Physaliæ*, pretty frequently associated with *Nomeus Gronovii*, which is not less pelagic than *Naucrates*. These little fishes, as well as the young of *Seriola*, *Coryphæna*, &c., are also met with in the floating masses of seaweeds. The young of *Naucrates* and *Nomeus* constitute the most frequent product of net-fishing in the open sea; and we thus possess numerous examples of them, which bear witness in favour of their wide geographical distribution. In *Nomeus* the changes arising from age and development are comparatively insignificant, but, perhaps, only because they occur so early that they have not hitherto attracted attention.

Porthmeus argenteus, of which our museum possesses an example 74 millims. long, from the coast of Guinea, is not, as has been supposed, a young form of *Chorinemus*, but of *Lichia amia*. As this species must be referred to a different genus from *Lichia glaucus*, we may very well leave to the latter the name of *Lichia*, and in future designate *L. amia* under that of *Porthmeus amia* (Lac.). On the other hand, *Lichia calcar*, Bl., of which I have before me a specimen 25 millims. long, is a young form of some *Chorinemus* of the Atlantic with four dorsal spines, perhaps *Chorinemus saliens*. The museum has received a corresponding series of a *Chorinemus* from the Indian Ocean 25–34 millims. long, with seven spinous dorsal rays, including successive stages up to the perfectly developed although still very young form. For the subdivision of this genus it would be best to employ a difference hitherto unnoticed (see the fig. on p. 512 of the Danish memoir), namely the existence or absence of teeth on the pterygoids side by side with those of the palatines and vomer, in accordance with the following scheme, the divisions of which must, however, only be estimated as sections or subgenera, and not as true genera :—

A. 4–5 (6) dorsal spines; scales linear; no teeth on the pterygoids. *C. occidentalis*, *saliens*, *palometa* (*Oligoplites*, Gill).

B. 7 dorsal spines, and teeth on the pterygoids.
  1. Scales linear: *C. tol* (*C. moadetta*, Klz., perhaps the young form of *C. tol*).
  2. Scales short and broad: *C. lyson*, *sancti Petri*, and a new species from Singapore which greatly resembles *C. altus* of the western coast of Central America.

In some species the teeth of the upper jaw are uniserial, and in others bi- or pluriserial; but those of the mandible are always biserial, although here a remarkable difference due to age makes its appearance; the older individuals are *homodont*, and the young *heterodont*. In other words, in the young *Chorinemi*, until they are about half-grown, the outer row in the mandible consists of very small, numerous, setiform teeth placed very close together (almost as in the Chætodonts), which are very different from the strong, conical, recurved teeth, separated by distinct intervals, and consequently much less numerous, of the inner row. During the growth of the fish these outer teeth are replaced by a new row of teeth, which, according to the species, are identical with, or more or less similar to those of the inner row. A somewhat superficial observation of these important modifications of the dental system, which depend upon the age of the individual, might easily lead to the establishment of unfounded specific distinctions. The pterygoidian teeth, mentioned above, likewise exist in the genus *Paropsis*; and this genus presents another peculiarity not previously mentioned, namely the ramification of the lateral line, which, however, seems to become less marked with increasing age.

10. Psenes, Cubiceps, and Navarchus.

It is already known that *Navarchus* is generically identical with *Atimostoma* and *Trachelocirrus*, as also that this genus falls into that of *Cubiceps*. But in the present state of science it is equally difficult to separate the genera *Psenes* and *Cubiceps*. Under these two names a series of species have been described which are for the most part young forms still unknown in the adult state, and which will no doubt have to undergo reduction. Among the rather numerous small pelagic individuals of the genus *Psenes* possessed by our museum, I have been able to distinguish five or six species; but I have only partially succeeded in referring them to those which have been described. I regard as new a high, short, and very compressed form, nearly colourless and semitransparent, from the Straits of Surabaya, *P. pellucidus*, sp. n. (figured p. 516 of the Danish memoir), which, I suppose, could not very well represent the juvenile form of a *Navarchus*. Another form very widely distributed in the Atlantic is represented in pl. v. fig. 2 (of the Danish memoir) ; I have made it provisionally a new species under the name of *P. maculatus*, but strongly suspect that it may be a young form of *Navarchus sulcatus* (*Cubiceps gracilis*), or of *Atimostoma capense* (species which are perhaps identical), or of some analogous form. We shall hardly deceive ourselves if we regard these three types (*P. maculatus*, *N. sulcatus*, and *A. capense*) as three successive stages of a single species, or, at any rate, of several very nearly allied species, which only appear rarely at the surface of the sea in their developed state, and which, in consequence, are still but little known to naturalists; perhaps, indeed, it is not precisely my *Psenes maculatus*, but another nearly allied form, which I have met with more rarely, and which is distinguished by a smaller number of rays in the vertical fins, that is really the young form of *Navarchus sulcatus* and *Atimostoma capense*. The group *Psenes-Cubiceps* is, in point of fact, one of the pelagic groups of which we know least, and with regard to which we have scarcely begun to lift a little corner of the veil which hides the rich ichthyological fauna of the great depths. In none of these young or more advanced forms of *Psenes* have I found a spinous præoperculum as in so many other young Scomberoids, and as is the case in the adult state with the præoperculum and interoperculum of a fish which appears to be very nearly related to *Psenes*, namely *Palinurichthys* (*Pammelas*) *perciformis*; there is nothing which seems to indicate that any of the forms of *Psenes* that have been described, or that I have examined, can be derived from that species, which is only known from specimens from the eastern coast of North America.

11. Stromateus, Apolectus; Schedophilus; Trachynotus; Micropteryx; Seriola.

The conjecture has already been put forward that the "*Rhombus crenulatus*," Cuv., is a young form of *Stromateus alepidotus* (*Gardenii*, *longipinnis*). Dr. Günther has also shown that *Stromateus securifer* is only a young *S. argenteus* (*candidus*); and the subordination on the same ground of *Apolectus stromateus* to *S. paru* is confirmed by the description of a little fish (13 millims.) from the Straits of Riouw, with large ventrals and the margin of the præoperculum denticulated, in which I have recognized a still younger form of the *Apolectus* and of *S. paru*. In consequence of these analogies, and depending in part upon the materials at my disposal, and in part on what I have found in the literature of the subject, it seems to me more than probable that *S.* (*Seserimus*) *microchirus*, with more or less rudimentary ventrals, is a young form of *S. fiatola*; but as this question, when once raised, may easily be elucidated by the ichthyologists of the Mediterranean coasts, I shall leave to them the task of solving it, and shall not discuss it further. With regard to the genus *Stromateus* I shall further remark that the separation effected by M. Bleeker of the three species *S. argenteus*, *cinerea*, and *sinensis* (*atous*, *albus*) as forming a distinct genus, *Stromateoides*, must be sustained. This genus is chiefly characterized by its short branchial clefts; young examples of *Stromateoides sinensis* also confirm the proposition, already advanced by M. Bleeker, that the ventrals, in this genus, disappear earlier than in the true *Stromatei*, if indeed they are not completely deficient. *S. medius*, Pet., is a true *Stromateus*, and not a *Stromateoides*.

The genus *Schedophilus*, which belongs to the true pelagic fishes, counts several (4) species; I shall abstain from discussing whether it may not be necessary to make them undergo some reduction. The pretty numerous specimens, chiefly young, that our Museum possesses must all be referred to *S. medusophagus*. The differences of age manifested in the proportions of the parts of the body, the system of coloration, &c. might certainly, if we examine them isolatedly, give rise to the establishment of illegitimate species; but they have no great importance from a general point of view.

The great differences arising from age, which, in the genus *Trachynotus*, have caused a series of false species, and even genera (*Doliodon*, *Bathrolæmus*) to be established, have already been dealt with by MM. Günther and Gill, and I have nothing essential to add. I shall only remark that *T. rhomboides* of the West Indies already has its rhomboidal physiognomy and its much prolonged sickle-shaped fins at an age when these prolongations of the fins are still rather short in the *T. ovatus* of the Indian seas, and that I am of opinion (with Mr. Gill) that these two species must be regarded, at least provisionally, as distinct. On the other hand, *Micropteryx* (*Chloro-*

scombus) *chrysurus* is not one of the forms in which the changes due to age can give rise to the establishment of deceptive species. Nevertheless the scapular and præopercular spines, which are characteristic of so many Scomberoids in the first phases of their development, are not wanting in the youngest individuals (10–25 millims.) of the series that I have examined.

The division indicated by G. Cuvier, and effected by Mr. Gill, of the genus *Seriola* into two distinct genera, *Zonichthys*, Swainson, and *Halatractus*, Gill, seems to be very natural. (*S. gigas* is the type of a third genus, *Naucratopsis*, Gill; and *S. Dussumieri* and *succincta* are young forms of *Naucrates ductor*). To the genus *Zonichthys* belongs *S. nigrofasciata* (with which *S. intermedia* is no doubt to be united); the genus *Halatractus*, or *Seriola* proper, includes *S. Dumerilii*, Risso (with which I identify not only *S. purpurascens*, Schl., but also *S. Solandri*, C. & V.), *S. quinqueradiata*, Schl., *S. zonata*, Mitch. (*carolinensis*, Holbr.), and *S. rivoliana* (*S. Boscii*, *falcata*, and *bonariensis* perhaps do not differ from this last species). *S. tapeinometopon* (an example 73 millims. long from the Indian Ocean) is no doubt only a young form of *S. Dumerilii*, with the transverse bands which are characteristic of so large a number of young Scomberoids. Young *Seriolæ* are tolerably frequent in our pelagic collections; the entire group may therefore no doubt be regarded as subpelagic, and certain forms (such as *S. rivoliana*) as completely pelagic. Besides several more or less juvenile forms of *S. Dumerilii* and *S. rivoliana*, our museum possesses very young forms (19–26 millims.) with the head armed with very large spines, and greatly resembling the so-called *Xystrophorus* phase of *Naucrates*; I have referred them to *S. zonata* (*carolinensis*); lastly, young spinous forms of *S. nigrofasciata* and *S. quinqueradiata*, with regard to which I refer to the figures (pl. iv. figs. 7–11 of the Danish memoir) for the greater or less differences in physiognomy, the system of coloration &c. which distinguish them from the adults. I think also that we must refer to the subpelagic forms the *Seriolichthys bipinnulatus* (the præoperculum of which, notwithstanding what has been said, is not denticulated), as having been observed not only in the Indian Ocean, but also in the Mediterranean and the West Indies. The *Seriolellæ* having been identified with the *Neptomeni* by Dr. Günther, we must suppose that the armature of spines indicated in them likewise does not constitute a permanent character.

12. Caranx, Carangichthys; Gallichthys; Selene (Argyreiosus, Vomer).

In the *Caranx* group too many and too few genera have been established. Following the principles adopted by certain authors, we might establish still more of them; for several undescribed species represented in our museum must furnish types for new divisions; on the other hand, we cannot approve of suppressing them all. A critical revision allows us to retain the six following genera:—

1. *Trachurus*, Cuv. (Gthr.). The lateral line is cuirassed throughout its whole length. The species of this genus have erroneously been united into a single one; I am able to distinguish the following:—*T. Linnæi*, Malm, the form from the Northern seas, which, however, is also met with in the Mediterranean; *T. mediterraneus* (Steind.), which also probably occurs in the Northern seas, where, however, it is certainly rare; *T. Cuvieri*, Lowe (Madeira, West Indies, west coast of South America); *T. japonicus*, Blkr. (China, Australia). The relative proportions between the two parts of the lateral line, its more or less sudden or oblique inflexion, and the height of the plates in proportion to their breadth, furnish good specific characters.

2. *Megalaspis*, Blkr. With 8–9 finlets separated from the dorsal and anal.

3. *Decapterus*, Blkr. A single finlet (the last ray of the fin) separated from the dorsal and anal.

4. *Caranx*, Cuv. Lateral line incompletely cuirassed as in 2 and 3; no isolated finlets. *Carangichthys* is only a young *Caranx* with the præoperculum denticulated. This genus has been divided into a great number of subgenera, which it would be superfluous to enumerate, and which ought all to be suppressed.

5. *Gallichthys*, Cuv. Naked, or nearly scaleless; the first dorsal is rudimentary in young individuals, and altogether wanting in the adults. *Blepharis*, *Scyris*, *Hynnis*, &c. are founded upon differences arising from age, and must consequently be eliminated.

6. *Selene*, Lac. (*Vomer*, *Argyreiosus*, &c.).

The young of *Caranx* and *Trachurus*, down to a length of 10–14 millims. for the smallest, are often brought by the sailors, and we thus possess a great number of them; but it is not possible to determine their species with exactitude except when they occur in more complete series, which enable us to recognize the characters of the adult. In my memoir I indicate the differences arising from age that I have observed in certain species, especially from the West Indies; and these, considering the difficulty of distinguishing from each other the species belonging to these genera, merit some attention. The youngest individuals with no scales or lateral line, and with a spinous præoperculum, certainly do not present any character which enables us to decide whether they are *Trachuri* or *Caranges*. The species in which I have observed the greatest changes during growth and development is *C. armatus*; but they are already in great part well known, and I shall not here examine them in more detail. These changes are, however, very inferior to those observed in the *Gallichthyes*, which have been divided into more genera than there are species in reality, because the successive stages which recur in an analogous manner in the different species have been interpreted as constituting so many separate generic types—the result of which has naturally been that the diagnoses of the species have become as incorrect as possible, and that systematic confusion has attained its final limits. Each of the three or four existing species passes through a phase of *Blepharis* (*Gallichthys*), one of *Scyris*, and one of *Hynnis*. *Hynnis goreensis* is thus the adult form of *Gallichthys œgyptiacus* and of *Scyris alexandrinus*; the forms described by Poey under the names of *Scyris analis* and *Hynnis cubensis* correspond in the same way to *G.* (*Blepharis*) *crinitus*. The *Scyris* phase belonging to *G. ciliaris* has not been before described. It may be asked (but, owing to the want of sufficient materials, I cannot decide the question) whether *G. ciliaris* of the Indian Ocean differs specifically from the American *G. crinitus*. If these two forms, comparatively rare in the adult state, are, as I suppose, fishes which inhabit tolerably deep water, we can understand that the same species might occur in seas far distant from each other. The general rule which finds its expression in the changes of form produced in this genus may be summed up as follows:—Greater and greater elongation of the body, so that its original proportions are completely altered; reduction of the number of spinous rays in the dorsal and anal fins, as also of the filamentous prolongations of the ventrals, and, later on, likewise of those of the dorsal and anal.

Exactly similar changes occur in the genus *Selene*, Lac. (p. p.) (= *Argyreiosus*, *Vomer*, *Platysomus*); and in consequence "analogy" and "affinity" have been until very lately confounded in them as in *Gallichthys*; nay, more, after Dr. Günther had elucidated the filiation of the forms in the essential points, the justice of his views was contested, and the error again maintained with a certain emphasis.

Leaving out of consideration *Argyreiosus dorsalis*, with regard to which I will not attempt to decide whether it is a variety of *Selene setipinnis* or a distinct species, it seems to me evident, from all that I know in nature and from literature, that instead of four species there are only two on the east coast of America, namely *Selene* (*Argyreiosus*) *vomer*, Linn., and *S. setipinnis*, Mitch. (*Vomer Brownii*). I have illustrated by two series of figures (pp. 543 and 547 of the Danish memoir) the development of these two species and the changes they undergo with age. The young form of *S. setipinnis* has been described under the name of *Argyreiosus unimaculatus*; if consistency had been desired it might have been set up as a distinct genus; the very old form of the same species is *Platysomus micropteryx* of Swainson. *Argyreiosus vomer*, L., *Zeus rostratus* and *Argyreiosus capillaris* of Mitchill, *A. Spixii*, Cast., *triacanthus* and *Mauricei*, Sw., and *senegalensis*, Guich., are all one and the same species, *Selene vomer* (L.), which, in its complete development, is represented by the *Selene argentea*, Lac., described by Brevoort. The two species attain nearly the same size (2 feet), and follow a very parallel course in their evolution—with this reservation, however, that the successive stages present greater differences among themselves in *S. vomer* than in *S. setipinnis*, and that the principal changes are earlier accomplished in this latter species. As will be seen from the figures, the young forms of the two species have the body very short and thickset; the first dorsal and the ventrals are well developed, and have filamentous prolongations in *S. vomer*; with age the body extends more or less in length, and the ventrals as well as the first dorsal are reduced to a minimum, while the pectorals become elongated, and the first ray of the anal and that of the second dorsal acquire an enormous length, in *S. vomer*. Thus, in proportion as the form of the body is modified, the prolongations of the fins which in the young perform the office of instruments of movement or of balancement, are replaced in the adults by prolongations of the same nature, but developed elsewhere. Both species occur on the west coast of Africa, and they have also been met with on the west coast of America. I must, however, remark that the species from Nicaragua possessed by our museum, and which there represents *S. vomer*, is a distinct species (*S. Oerstedii*, m.), distinguished by a peculiar profile and by the number of its rays (D. 8 . 1 . 18 ; A. 1 . 15).

13. Zeus; Zenopsis (Lampris; Mene).

A critical comparison of the materials in the possession of our museum, in the form of fishes from St. Pierre, in the

Mediterranean, combined with the statements contained in literature, has led to a fresh examination of a question which has also been raised elsewhere—namely, whether *Zeus faber* and *Z. pungio* must really be considered distinct species, or only varieties with a more or less local character. It is clear that the differences which have been appealed to are not characters relating to sex or age; but at the same time it results, from the examination that I have made, that *Z. pungio* can, at the utmost and even with difficulty, be regarded only as a variety of *Z. faber*, and by no means as a distinct species—an opinion which seems to be shared by the greater number of the Italian ichthyologists. The only somewhat constant character is the form and size of certain scutes at the base of the second dorsal. On the other hand, I must maintain that *Z. australis*, Rich. (Australia), is a perfectly different species from *Z. faber*, but perhaps identical with *Z. japonicus*; whether *Z. capensis* is a third species, or to be combined also with *Z. australis*, is a question still to be solved; in any case it will belong to a species distinct from *Z. faber*. It is no doubt with good reason that Mr. Gill has established the genus *Zenopsis* for the species more exclusively inhabiting the deep waters (which can hardly be said of the true species of *Zeus*), such as *Z. conchifer* (Madeira, with *Z. ocellatus* of North America) and *Z. nebulosus* (Japan); but the right of these species to be considered distinct still needs revision, which is the more necessary as the characters indicated are of rather doubtful value, and as we have here to do with species inhabiting the great depths of the oceans, and the geographical distribution is often very extensive in the fish of this category. I shall refer finally to the note by Dr. Günther on a supposed juvenile form of *Mene maculata*, a note which is, so to speak, the harbinger of the interesting particulars which the future will no doubt bring us as to the hitherto unknown metamorphoses of the genera *Zeus* and *Lampris*.

14. Psettus; Zanclus and Gnathocentrum; Platax.

Dr. Günther has already demonstrated that *Gnathocentrum*, Guich. (*Zanclus canescens*, L.), is only a young form of *Zanclus cornutus*; nevertheless the late M. Bleeker, in his 'Atlas Ichthyologique,' still separates them as distinct species. I have therefore thought it right to state that for me also it is an established fact that the genus *Gnathocentrum* and *Z. canescens* are respectively only the young stages of the genus *Zanclus* and of *Z. cornutus*.

Other authors have already pointed out that it is an error to deny palatine teeth to the genus *Psettus*. The four species which constitute it are all armed with five very considerable groups of card-like teeth on the vomer, the palatines, and the pterygoids. These four species are:—the true *P. rhombeus* of Forskål from the Red Sea and the Mauritius (figured in the illustrated edition of Cuvier's 'Règne Animal,' pl. xlii. fig. 2), which authors, except the late Sir John Richardson, have erroneously confounded with *P. argenteus*, Linn., from the East Indies, Australia, and China (see 'Voyage of the Erebus and Terror,' pl. xxxv. fig. 1); *P. falciformis*, Lac., from the East Indies, and *P. sebæ*, C. & V., from the west coast of Africa.

The species of the genus *Platax* are subject during their growth and development to such considerable changes, both in physiognomy and in the form of the body and the coloration, that great confusion and the establishment of a number of nominal species could not but result from them. Nevertheless more light has by degrees been thrown upon this question; and in this respect I may refer especially to M. Bleeker's text and the very instructive plates of his great 'Atlas Ichthyologique.' But (and this is a singular fact) he has neglected a character of which M. Klunzinger first indicated the importance, and without which we shall never arrive at a certain determination of the species. In some species (*P. teira*, Forsk.) the three points of the teeth of the outer row are of the same size; in others (*P. vespertilio*, Bl., =*orbicularis*) the middle point is very distinctly larger; in others, again (*P. batavianus* and *P. pinnatus* (L.), Blk.), it is much larger than the others and completely predominant. It would not appear that we know more than these four species; M. Blecker's fifth species (*P. melanosoma*) is only known from a very young specimen; and the author (whose recent loss is so much deplored) himself regarded it as doubtful.

15. Scomberesox saurus.

Dr. Günther having already indicated, although very briefly, the metamorphoses of this fish in their principal features, I may here confine myself to referring to the figures on p. 567 (of the Danish memoir), which represent the different phases of the evolution of the rostrum, as also the physiognomy of the entire fish in one of its youngest stages; and as they are accompanied by a corresponding series of figures representing the very well-known evolution of the same parts in the common Garfish (*Belone vulgaris*), the analogies and differences between the development and transformation of these two nearly allied fishes will strike the eye at once without need of further explanation. I will only add that *Scomberesox saurus* is in the highest degree a pelagic fish, the young of which, easily recognized and impossible to confound with any others, are captured everywhere between the tropics, and even beyond them, especially the youngest forms. It is therefore not difficult to obtain a series of all the successive stages of this genus. Nevertheless, in this great accumulation of more or less juvenile forms derived from very widely separated parts of the great seas of the globe, I have been unable to distinguish more than one species, and have come to the conclusion that, properly speaking, we only know a single species belonging to this genus, namely the pelagic and essentially cosmopolitan species known under the name of *S. saurus* or *S. Camperii.* I must, however, make an exception in favour of *S. brevirostris* of California, a very distinct species described by M. Peters, which is distinguished by an excessive abridgement of the two jaws, a peculiarity to which we find an analogue in the young of *S. saurus* in a certain stage of evolution. A critical examination of the characters indicated for the other species of *Scomberesox* also seems to show that they do not rest upon a very solid basis; but I must leave it to the ichthyologists of the shores of the Mediterranean to elucidate from this point of view the case of *S. Rondeletii* and its relationship to *S. saurus* of the Atlantic. The anatomical character upon which its separation as a distinct species is founded has not, so far as I know, been verified since it was established by M. Valenciennes; hence it does not appear to have any real foundation; and the *Scomberesoces* from the Mediterranean that I have examined possessed a swim-bladder like those of the ocean.

Another eminently pelagic form of this group is *Euleptorhamphus longirostris.* There is therefore a certain probability in favour of the opinion that all the different species which have been established in this genus from individuals fished in the two great oceans at points very distant from one another are only representatives of a single pelagic and cosmopolitan species; but for the more satisfactory verification of this supposition it would be necessary to have at command more considerable materials than any museum at present possesses.

16. Pomacanthus; Holacanthus; Chætodon; Tholichthys; Ephippus.

On the shores of the Antilles there live two species of *Pomacanthus* which are certainly distinguished at all ages by positive and non-equivocal characters, but which in habit, coloration, pattern, squamification, &c. undergo changes so profound and so analogous that we cannot be surprised if ichthyologists on the one hand have created a great number of nominal species, and on the other have not succeeded in separating from each other the very analogous young forms belonging to the two species. The natural consequence of this has been that the connexion between the young and older forms being incapable of being overlooked by those who had sufficient material at their command, authors have fallen into the extreme opposite mistake, and united the two species, including all the phases of their development, under a single species including a whole series of varieties. The considerable materials contained in our two zoological museums now combined (the Royal Museum and that of the University) have enabled me to study the distinctive characters of *P. paru*, Bl., and *P. aureus*, Bl., at all ages, and to confirm, with some modifications, the correctness of the views put forward on this question by MM. Bleeker and Poey.

Holacanthus ciliaris is subject to analogous changes; and *H. formosus* of Castelnau is evidently only a young form of this species. On the contrary, the changes due to age are comparatively insignificant in *H. tricolor*; the young individual represented in pl. v. fig. 6 (of the Danish memoir) has the same large ocellated spot which distinguishes many young Chætodonts. As to the secondary squamification, *Holacanthus ciliaris* stands in the same relation to *H. tricolor* as *Pomacanthus aureus* to *P. paru*. Neither of these genera, so far as we know, passes through the so-called "*Tholichthys*" phase; and it is hardly probable that this case occurs in them.

On the other hand, this phase occurs in so great a number of true Chætodonts, that there can be no doubt it is common to them all. Among the larvæ of Chætodonts or "*Tholichthyes*" that I have had before me I will mention two. One of them (pl. v. fig. 8 of the Danish memoir) represents, in my opinion, one of the stages of *C. sedentarius*, Poey (*gracilis*, Gth.), or of some little-known nearly allied species: the other (fig. 10) I have referred to *Parachætodon ocellatus* (C. & V.); and it would then represent that species in a still younger stage than those at present known, distinguished, among other things, by this peculiarity, that the supraorbital margin terminates in a spine directed obliquely sideways and backwards. Like the Chætodonts, the species of the genera *Ephippus* (*Scatophagus*), *Harpochirus*, and *Chelmo*, after having completely passed through the "*Tholichthys*" phase, so far as such a phase exists, undergo modifications, in the form of the body, the coloration, &c., which merit attention, because they are always sufficiently great to give rise to the establishment of false species when one has not sufficient materials at command. *Ephippus argus* appears to me, however, to include three species:—the Chinese form, with a small number (20–30) of large spots; the East-Indian type species, with many spots of moderate size; and a form from the Sunda Islands with numerous small spots, a pattern which, in young individuals, changes into transverse bands (*E. ornatus*). Strictly speaking we cannot characterize our youngest *Ephippus* as a "*Tholichthys*;" but nevertheless it has so many points in common with this phase of *Chætodon* that we may describe it as being in a "Tholichthyoid" phase. It somewhat resembles a *Chromis* or a *Pomacentrum*: the body is short, squat, and much compressed, the profile of the head nearly vertical, the skin rough and without scales; the fins are naked; the pattern consists of dark transverse bands; the forehead is broad, convex, and protected by two thick, rounded, triangular shields, which meet in the median line, but which, posteriorly, embrace between them the apex of a parietal boss; there is also on each side a temporal boss accompanied by a stout spine, which is the inferior extremity of a triangular suprascapular tubercle; the prolongation of the operculum (*i. e.* of the præoperculum and interoperculum) is divided by a notch into two short rounded parts, of which the superior is directed backwards, and the inferior inwards and downwards.

17. Acanthurus, Naseus; Acronurus, Keris.

We now know that *Keris* and *Acronurus* are respectively only the young forms of *Naseus* and *Acanthurus*. With regard to the development of the *Kerides* and their transformation into *Naseus* I may refer to the illustrations which accompany the magnificent work that Dr. Günther is publishing under the title of 'Fische der Südsee. There are numerous analogies between the young individuals of the two genera—the form of the body, which is short, with strongly arched contours, the streaking and partial metallic lustre of the skin, the greater length of the anterior dorsal and anal spines, the different position of the ventrals relatively to the pectorals, &c. My own contributions to the history of the metamorphoses of the genus *Acanthurus* consist in the indication of the so-called "*Acronurus*" form of the two West-Indian species, *Acanthurus chirurgus* (*phlebotomus*) and *A. cæruleus*, and of the still more curious form under which the so-called "*Acronurus*" shows itself in its first phase. In fact I regard as a young example of *A. cæruleus*, Schn., the very marked form of *Acronurus* represented in pl. v. fig. 4 (of the

Danish memoir), which was captured in the western part of the Atlantic in the neighbourhood of Brazil; it is 34–37 millims. long, discoid, nearly orbicular, colourless, with a silvery band, &c. The most serious objection that could be raised to this interpretation is the presence of a very different young form (pl. v. fig. 3), not larger, and sometimes even smaller, which, however, notwithstanding its small size, is already in a comparatively more advanced stage, transitional between *Acronurus* and *Acanthurus*, and which must with absolute certainty be referred to *A. cœruleus*. Whether this apparent contradiction arises from the circumstance that we have to do here with different though nearly allied species, or is due to the fact that the metamorphosis may take place a little earlier or a little later, is a question which I shall leave undecided for the present. Another, younger specimen of the same form, perhaps of the same species, but captured N.N.E. of the Bermudas, and characterized especially by the comparatively enormous development of the anterior (strictly the second) spine of the dorsal and anal, which gives these little nearly rhomboidal fishes a very peculiar aspect, makes known to us the "*Acronurus*" phase at a period still less advanced, and which cannot be very far distant from the time of exclusion from the egg.

As a contribution to the evolution of the *Acanthuri* I must also cite the change which the dental apparatus undergoes in *A. strigosus* (*ctenodon*). The adult fish presents this peculiarity—the teeth are pectinated only on one side; the young individuals still in the "*Acronurus*" phase have them pectinated on both sides. As these little fishes pass from the stage of *Acronurus* to that of *Acanthurus* the teeth with unilateral pectination make their appearance and predominate over those with double pectination.

18. Fistularia villosa; Centriscus velitaris and brevispinis; Centriscops and Orthichthys.

Fistularia villosa of Klunzinger is only a young form of *F. serrata*, Cuvier. The small close-set spines which clothe its skin occur also in young examples of *F. tabacaria*. It is not easy to differentiate these two species (of the east and west) in consequence of the modifications which their proportions undergo during growth &c.; but it is still more difficult to distinguish the two forms of *Aulostomus*, the specific value of which seems to me very doubtful.

Centriscus gracilis, Lowe, of which our Museum possesses several young examples from the Atlantic, south and north of the equator, must almost be regarded as a pelagic species.

The young individuals differ considerably from the adults by the shorter form of the body, their shorter tubiform muzzle, and by the well-marked development of the teeth, of the scutes of the skin, and of the hooked spines of the scales. There is no doubt that "*C. velitaris*," Pallas, is a nearly adult form, and *C. brevispinis*, Kn., Steind., a very young form of *C. gracilis*, and that these two specific names must disappear, as well as the genus *Orthichthys* of Mr. Gill. His genus *Centriscops* (type *C. humerosus*, Rich.) is better founded as regards the physiognomy, but is not based upon any important character or any special peculiarity of organization.

Finally, in a postscript, I refer to the considerable changes which occur in some groups of marine fishes which I have not had the opportunity of examining in this memoir, but which have been elucidated by other authors, or will be so, I hope, hereafter by myself. I may cite, for example, the metamorphoses (1) of the Pleuronectidæ, which have especially been elucidated by MM. Jap. Steenstrup and Alex. Agassiz; (2) of certain Gadoids; the *Couchiœ*, notwithstanding what may have been said, are the young of various species of *Motella*, and *Hypsiptera argentea* the young form of a Phycid; (3) of the *Macruri*, *Ophidia*, and *Trachypteri*, which have been elucidated by Mr. Emery; (4) of the Sunfish (*Mola rotunda* and *Ranzania truncata*), of which I hope soon to be able to give an explanation conjointly with M. Steenstrup; and, lastly, (5) of *Ansonia Cuvieri*, Risso (*Luvarus imperialis*), of which M. Giglioli has demonstrated that *Diana semilunata*, Risso (*Astrodermus coryphœnoides*), is the young form. This last is certainly one of the most remarkable of the transformations presented by the family of the Scomberoids, otherwise so rich in examples of this kind, to the knowledge of which I have also made some contributions in this memoir.

XI.—*Notices of British Fungi.* By the Rev. M. J. Berkeley, F.R.S., and C. E. Broome, Esq., F.L.S.

[Continued from ser. 5, vol. iii. p. 212.]

[Plate III.]

1833. *Agaricus* (Amanita) *nitidus*, Fr.

Mattishall, Rev. J. M. Duport.

Several specimens have been forwarded, some exactly agreeing with the definition of Fries in the thick indurated angular warts, while others approach so near to *A. mappa* that it is difficult to distinguish them.

1834. *A.* (Lepiota) *granulosus*, Batsch, var. *rufescens.*

A curious form was found near Bristol by Mr. Bucknall, quite pure white at first, then partially turning red, and in drying acquiring everywhere a rufous tint.

1835. *A.* (Lepiota) *seminudus*, Lasch.

Clifton, Mr. Bucknall. Coed Coch, 1880.

1836. *A.* (Lepiota) *Bucknalli*, B. & Br. Olidus, pileo e campanulato convexo, albo, stipiteque deorsum pulvere lilacino conspersis, lamellis albis marginem vix attingentibus.

Pileus nearly 1 inch across; stem 3 inches high, dilated at the base. A doubt has been suggested whether this may not be Quélet's var. *lilacinus* of *A. seminudus*; but as he does not mention the strong gas-tar smell, they cannot be the same. The spores in this species are much longer, ·00027 by ·0001, in *A. seminudus* ·00015 by ·00007 inch.

1837. *A.* (Armillaria) *focalis*, Fr.

On bare ground under old laurel trees. Coed Coch.

Pileus 4 inches across, pale fawn-coloured, darker above, slightly virgate, *extreme* margin involute; stem 5 inches high, 1½ inch thick at base, variously lacerated; mycelium white, fibrillose, ring very broad (to which the specific name alludes), superior; odour farinaceous; substance tender. Almost agreeing in dimension with the var. "*Goliath*," and certainly one of the finest British species.

1838. *A.* (Tricholoma) *stans*, Fr.

This species was formerly called by Fries *A. pessundatus*, and was found of large size at Coed Coch. The figure in the 'Icones' marked "*pessundatus*" is now referred to *A. stans.* The true *A. pessundatus* was sent by Mr. Renny from Lucerne.

1839. *A.* (Tricholoma) *guttatus*, Schæff.

This curious species was found at Downton by Mr. Howse, who brought an excellent drawing to the meeting at Coed Coch.

1840. *A.* (Tricholoma) *tumidus*, P.

Coed Coch. Exactly according with Krombholz's figure.

**A.* (Tricholoma) *lixivius*, Fr.

There is no doubt that Sowerby's *A. compressus* is this species.

1841. *A.* (Clitocybe) *hirneolus*, Fr.

Coed Coch, Oct. 1877.

1842. *A.* (Clitocybe) *amarus*, Fr.

Holm Lacy, Mr. Perceval, 1878.

1843. *A.* (Clitocybe) *pithyophilus*, Fr.

Coed Coch, 1880.

1844. *A.* (Clitocybe) *cryptarum*, Letellier. Dense cæspitosus, pileis subconicis depresso-flocculentis brunneis maculatis; stipitibus albis substriatis virgatis sursum attenuatis plus minus compressis anguste fistulosis; lamellis angustis arcuatis subdecurrentibus albis.

Coed Coch. On sawdust. Habit that of *A. tumulosus*. Pilei varying much in size, according to the denseness of the clusters. Inodorous, insipid; stem mottled within.

1845. *A.* (Clitocybe) *decastes*, Fr.

Coed Coch. On sawdust. Agreeing closely with the figure of Fries in the 'Icones;' but we are doubtful whether what we find is not an advanced stage of *A. cryptarum*—a matter which requires future observation.

1846. *A.* (Clitocybe) *Trogii*, Fr. (*A. suaveolens*, Trog).

Coed Coch. The colour approaching that of *A. metachrous*.

1847. *A.* (Clitocybe) *senilis*, Fr.

Coed Coch, 1880.

1848. *A.* (Collybia) *macilentus*, Fr.

Coed Coch, 1880.

1848 *bis*. *A.* (Collybia) *stolonifer*, Jungh.

Perth, Dr. Buchanan White.

1849. *A.* (Mycena) *adonis*, Bull.

Garthewin, Mr. Brownlow Wynne. The scarlet form.

1850. *A.* (Omphalia) *hydrogrammus*, Fr.

Coed Coch, 1880.

1851. *A.* (Omphalia) *infumatus*, B. & Br. Pileo obtuso nec membranaceo e viridi infumato; stipite tenui, luteo; lamellis paucis latis decurrentibus distantibus luteis.

On bark. Amongst moss. Garthewin, Mr. Brownlow Wynne. Pileus 2 lines across; stem 1 inch high, not a line thick, dilated at the base, tomentose, especially below; gills about twelve, with smaller intermediate. Allied to *A. umbelliferus*, but quite distinct from all its varieties.

1852. *A.* (Omphalia) *offuciatus*, Fr.

Coed Coch, 1880.

1853. *A.* (Omphalia) *abhorrens*, B. & Br. Odor stercorarius; pileo umbilicato brunneo; stipite gracili concolori; lamellis decurrentibus.

Coed Coch. On lawn with *A. retostus*.

**A.* (Pleurotus) *ulmarius*, Bull.

A specimen was found in the Coed-Coch forage, agreeing with *A. tessulatus*, Bull. The spots arising from the presence of a species of *Fusisporium*; the same appearance, arising from the same cause, occurred in *Agaricus orcella*.

1854. *A.* (Pleurotus) *laurocerasi*, B. & Br. Ostreæformis, pileo sulcato brunneo, cute tenuissima; stipite obsoleto, lamellis venoso-connexis; sporis ovatis.

On the naked trunk of a laurel. Coed Coch, Oct. 14, 1879.

Pileus rather more than an inch across; the cuticle is extremely thin, and gives way at the furrows so as to expose the substance of the pileus. Spores ·0008 millim. long.

1855. *A.* (Pleurotus) *palmatus*, Bull.

The spores of this species are pale ochre-coloured, ·0004 inch in diameter; it has the same right to be placed in *Pleurotus* as the rosy-spored *A. euosmus.*

1856. *A.* (Pluteus) *spilopus*, B. & Br. Nanus, pileo brunneo ruguloso; stipite flexuoso atro-punctato; sporis globosis lævibus.

C. E. Broome. Allied to *A. nanus.*

1857. *A.* (Leptonia) *æthiops*, Fr.

Coed Coch, 1880.

1858. *A.* (Eccilia) *atrides*, Fr.

Hereford. This is not the plant figured by Quélet.

1859. *A. acetabulosus*, Sow.

This curious species has never been satisfactorily elucidated. The occurrence of an allied form from Swan River necessitates the proposition of a new section (*Acetabularia*) analogous to *Volvaria* and *Chitonia.* The spores in the original specimen of Sowerby, now (with the drawing) in the British Museum, are clay-coloured.

1860. *A.* (Pholiota) *erebius*, Fr.

This is clearly the same species with *A. denigritus*, the spores of which are brown.

1861. *A.* (Pholiota) *ombrophilus*, Fr.

Coed Coch, in great abundance. It has also been sent to Mr. Phillips.

1862. *A.* (Pholiota) *subsquarrosus*, Fr.

Found in Herefordshire by Mr. Howse, who brought specimens and a drawing to Coed Coch.

1863. *A.* (Pholiota) *tuberculosus*, Fr.

On Sawdust, Coed Coch (and therefore not rooting into wood as in the typical form), together with the ringless form figured by Schæffer.

1864. *A.* (Pholiota) *curvipes*, Fr.

On sawdust. Coed Coch, 1879–1880.

1865. *A.* (Inocybe) *muticus*, Fr.

Coed Coch. In great abundance, 1880.

1866. *A.* (Inocybe) *destrictus*, Fr.

Coed Coch, 1880.

1867. *A.* (Hebeloma) *mesophæus*, Fr.

Coed Coch, 1880.

1868. *A.* (Hebeloma) *nudipes*, Fr.

Coed Coch, 1880. M. Cornu also found specimens exactly agreeing with Kalchbrenner's figure.

1869. *A.* (Hebeloma) *firmus*, P.

Coed Coch, 1880.

1870. *A.* (Naucoria) *hamadryas*, Fr.

Specimens gathered by Mr. Plowright at Brandon appear to belong to this species, but have the fishy odour of one or two *Nolaneas.*

1871. *A.* (Naucoria) *abstrusus*, Fr.

On sawdust. Coed Coch, 1880.

1872. *A.* (Naucoria) *tenax*, Fr.

On a grassy walk. Coed Coch, 1879. Spores ovate, even.

1873. *A.* (Naucoria) *rubricatus*, B. & Br. Cæspitosus; ex albo rubricatus; pileis pusillis demum planiusculis, stipitibus gracilibus.

On decayed twigs or petioles. Hereford, Miss Ruth Berkeley, 1878.

1874. *A.* (Psalliota) *comptulus*, Fr.

Coed Coch, 1880. In several places.

1875. *A.* (Stropharia) *inunctus*, Fr.

A pale form occurred at Sibbertoft, which we should have been inclined to refer rather to *A. albocyaneus*; but the cuticle peeled off with the greatest ease, and after a heavy rain it dripped with gelatinous matter. It resembled greatly Fries's figure of *A. torpens*, var.

1876. *A.* (Hypholoma) *appendiculatus*, Bull., var. *lanatus.* A curious form occurred in a hollow apple-tree at Sibbertoft, densely woolly when young, traces of the woolly coat remaining at the apex when the pileus is fully expanded.

1877. *Coprinus narcoticus*, Batsch.

Shewsbury, W. Phillips. Smell highly disagreeable.

1878. *Cortinarius* (Myxacium) *salor*, Fr.

Coed Coch. In considerable abundance, but rather decayed. The base of the stem was strangely swollen, showing the original universal veil halfway up the swelling, which ends abruptly. The head still covered with the bluish slime.

1879. *C.* (Myxacium) *illibatus*, Fr.

Coed Coch. A single specimen only.

*C. (Dermocybe) *myrtillinus*, Fr.

Coed Coch. At first sight resembling *A. nudus*, but known by the colour of the spores and the veil.

1880. *C.* (Telamonia) *impennis*, Fr.

Amongst dead leaves. Bomere, W. Phillips. Mr. Houghton sent from Tibberton Firs a species exactly intermediate between this and the common *C. torvus.*

1881. *C.* (Telamonia) *flabellum*, Fr.

Coed Coch, 1880. A single specimen.

1882. *C.* (Telamonia) *paleaceus*, Fr.

Coed Coch, Hereford, &c. Apparently a very variable species.

1883. *C.* (Hydrocybe) *jubarinus*, Fr.

Coed Coch. Abundant early in 1879.

1884. *C.* (Hydrocybe) *fasciatus*, Fr.

Coed Coch. Umbo very acute.

1885. *Hygrophorus sciophanus*, Fr.

Coed Coch. Small specimens. Gigantic specimens of this occur near Geneva, as found by Mr. Renny, with a darker form, of both of which we have excellent drawings.

1886. *H. subradiatus*, Schum.

Salop, W. Phillips, Esq.

1887. *Lactarius intermedius*, Krombh.

Norfolk, the Rev. J. M. Du Port and Mr. Plowright.

The specimens agree with Krombholz's plant, except that when fresh and dried they are more or less zoned as in *L. insulsus.*

1888. *Russula Queletii*, Fr.

Very common, confounded probably with *R. rubra.*

1889. *Marasmius urens*, Fr.

A curious form with the pileus becoming very dark when fully grown, and exceedingly acrid, occurred in a hothouse at Coed Coch in profusion for many weeks in September and October, with the white form of *A. cepæstipes* and *A. meleagris.*

**Lentinus fimbriatus*, Curr.

On a stump. Edenbridge, J. Renny, Aug. 1879.

1890. *Polyporus* (Resupinati) *umbrinus*, Fr.

Knowle Park, Burchell.

1891. *P.* (Resupinati) *reticulatus*, P.

Hereford, 1878.

1892. *Dædalea aurea*, Fr.

Hereford. Imbricated, the veins for the most part straight and radiating.

**Hydnum rufescens*, Fr.

Dolgelley, Miss Ruth Berkeley. Differing from *H. repandum* in having the pileus distinctly tomentose, in this case studded with little villous warts.

1893. *H. acre*, Quélet.

Forres, Rev. J. Keith, 1878.

* *Thelephora intybacea*, P.

Glamis, Rev. J. Stevenson.

1894. *Cyphella Bloxami*, B. & Phill. Alba floccoso-membranacea, disco flavescente crenato-lobato; floccis lævibus; sporophoris turbinatis.

On *Ulex*, Twycross, Rev. A. Bloxam.

Spores ·0003–·0004 inch. Spores terminating slightly branched threads.

1895. *Clavaria canaliculata*, Quélet.

Coed Coch. In several places; the same species was sent by Mr. Renny from Lucerne.

* *Geaster limbatus*, Fr.

Garthewin, Denbighshire, Mr. Brownlow Wynne.

1896. *Myxosporium dracænicola*, B. & Br. Aurantium, sporis ovatis.

On leaves of *Dracænæ*, spores ·00035 inch long, ·0002 wide. On the same leaves, scattered in the form of minute black specks, was a *Diplodia* with oblong uniseptate spores, slightly constricted in the middle, colourless, and probably immature, ·0006–·0007 long. These are doubtless states of more perfect fungi, but are mentioned here because they are connected with a disease which seems fatal to *Dracænæ*.

1897. *Glœosporium cytisi*, B. & Br. Maculis albis quandoque rubro-cinctis, peritheciis minutis, sporis minutis ellipticis.

On *Cytisus laburnum*. Glamis, Rev. J. Stevenson.

1898. *Protomyces melanodes*, B. & Br.

On leaves and inflorescence of *Phlox* (Gard. Chron. Sept. 1879).

1899. *Cryptosporium turgidum*, B. & Br. Peritheciis globosis prominulis obtusis; sporis curvis utrinque acutis, obscure triseptatis.

On ash, Rev. A. Bloxam. Spores ·0008 long.

1900. *Sporonema phacidioides*, Desm.

On leaves of *Medicago maculata*, Wimbledon.

1901. *Leptothyrium asterinum*, B. & Br. Maculæforme incrassatum margine rubro, sporis oblongis curvatis binucleatis, ·001–·0015 long.

Plate III. fig. 1. Spores and flocci, highly magnified.

On *Aster tripolium*. Fleetwood, Rev. A. Bloxam.

1902. *Septoria violæ*, Rab.

On leaves of *Viola canina*, Fergusson.

1903. *Gymnosporium lateritium*, B. & Br. Effusum, lateritium, sporis obovatis breviter pedicellatis.

On wych elm. St. Catherines, C. E. Broome. Looks like a stratum of finely powdered brickdust. Spores ·0003 long.

1904. *Selenosporium tubercularioides*, Cd.

On raspberry. Orton Wood, Rev. A. Bloxam.

1905. *Uredo plantaginis*, B. & Br. Maculis pallidis, pustulis minutis apice tantum ruptis; sporis ellipticis luteis.

On *Plantago*, Woodnewton. On *P. lanceolata*, Dolgelley, Ralfs.

1906. *Isaria floccosa*, Fr.

On a caterpillar. Milton, Norths., Mr. J. Henderson.

1907. *Fusarium equiseti*, Desm.

Oswestry. Spores at first ·0002 long, at length ·0015.

Plate III. fig. 2. *a*, flocci with young spores; *b*, spores, young and old.

1908. *T. salicinum*, Cd.

On willow. Twycross, Rev. A. Bloxam.

1909. *Monotospora elliptica*, B. & Br. Punctiformis, sporis ellipticis binucleatis quandoque uniseptatis.

On herbaceous stems.

Plate III. fig. 5. Flocci with spores, highly magnified.

1910. *Helminthosporium molle*, B. & C., Notices of new Am. Fungi, p. 113.

On *Ilex*. Powerscourt.

1911. *Chalara longipes*, Strauss.

On old walnuts &c., Dr. Buchanan White. We cannot identify this with any of the species figured by Saccardo.

1912. *Aspergillus griseus*, Lk.

Kings Cliff. On various decaying substances.

1913. *Penicillium saponis*, B. & Br. Nigrum, monilibus e cellulis 2–3 oriundis; sporis globosis.

On soap, Rev. J. Hort.

Plate III. fig. 3. Plant, highly magnified.

1914. *P. abnorme*, B. & Br. Candidum, floccis tenuibus in corpus turbiniforme desinentibus, sporis minutissimis.

On leaves of *Trientalis europæa*.

Plate III. fig. 4. Flocci with their receptacles and spores, highly magnified.

1915. *Zygodesmus terrestris*, B. & Br. Fuscus, sporis subellipticis vel citriformibus, primum lævibus, demum asperulis.

On bare chalk. Crundall, Kent. We have also had the same from Dr. Montagne, marked Haddous. Forming a thin brown stratum.

1916. *Peronospora dipsaci*, Tul.

On *Dipsacus sylvestris*.

1917. *Ramularia veronicæ*, B. & Br. Tota alba, floccis brevibus, sporis oblongis angustis deorsum leviter attenuatis.

On *Veronica agrestis*, Sibbertoft. This and *Peronospora* *obliqua*, Cooke, clearly belong to the genus *Ramularia* as revived by Saccardo.

PLATE III. fig. 7. Flocci and spores, highly magnified.

1918. *Coccotrichum brevius*, B. & Br. Cæspitulis subglobosis rufis, floccis parce ramosis articulatis, articulis brevibus, sporis ellipticis granulatis.

Leigh Wood, on bark, C. E. Broome.

Of a rich red-brown; when placed in water it tinges it with the same colour. When young the tufts are distinct; they afterwards become confluent. When dry they assume a buff or ferruginous tint.

PLATE III. fig. 8. *a*, plant, natural size; *b b*, flocci with heads of spores, magnified; *c*, spores, highly magnified.

1919. *Polyactis capitata*, B. & Br. Tota alba, floccis ex articulis tumidis basi sitis oriundis trifidis bifidisque, sporis obovatis.

On *Cheiranthus*, Sibbertoft. Spores ·001 long.

1920. *Stachylidium trabeum*, B. & Br. Pallidum, floccis parce ramosis, apicibus 3–4fidis, sporis globosis.

On an old beam. Kings Cliff, Nov. 15, 1864.

PLATE III. fig. 6. Flocci with spores, highly magnified.

1921. *Helvella Klotschei*, Cooke.

A single specimen in the Fernery, Coed Coch, Mrs. Lloyd Wynne, which was submitted to Dr. Cooke for identification.

* *Verpa digitatiformis*, P.

With *Morchella gigas*, M., and the following. In some of the specimens the head is minutely reticulated, as it has also occurred to Mr. Broome.

1922. *V. speciosa*, Vittadini.

Coed Coch. Agreeing in size and colour with Vittadini's figure; but the sporidia are not oblong, so that there is some doubt about the species.

1923. *Dermatea cinnamomea*, DC.

On maple. Leigh Wood, Dec. 1878.

Sporidia ·0015–·00045 long, finely granulated.

1924. *Cenangium Rubi*, Dub.

Glamis, Rev. J. Stevenson.

1925. *Eurotium lateritium*, Lk.

Dolgelley, J. Ralfs.

1926. *Sphæria Stevensoni*, B. & Br. Nigra, fragilis, sparsa, subglobosa, glabra; sporidiis oblongis, 2–3-septatis.

On dead wood. Glamis, Rev. J. Stevenson. Sporidia ·0002 long. Under the lens it splits with pressure into several fragments.

XII.—*On a Collection of Butterflies from Nikko, Central Japan.* By Arthur G. Butler, F.L.S., F.Z.S., &c.

The following is an account of a large series of Butterflies collected by Mr. Charles Maries in Nippon (or Niphon) Island, and certainly one of the richest of any collection which has hitherto come to England, since it contains no less than 118 species.

Mr. Maries also collected in the island of Yesso, where he obtained the *Satyrus Schrenckii* of Ménétriés and other rare species, and again in the province of Kiukiang, China, where he captured a good series of *Papilio alebion*, a new species allied to the latter, a pair of *Luchdorfia puziloi*, and other rarities, all of which are now in the collection of the British Museum.

List of Species obtained in Nikko.

1. Danais tytia, *Gray.*
2. Melanitis ismene, *Cram.*
3. Satyrus bipunctatus, *Motsch.*
4. Neope Gaschkevitchii, *Mén.*
5. —— niphonica, sp. n.
6. —— callipteris, *Butl.*
7. Pararge deidamia, *Eversm.*
8. —— achinoides, *Butl.*
9. Lethe diana, *Butl.*
10. —— Whitelyi, *Butl.*
11. —— consanguis, sp. n.
12. —— sicelis, *Hew.*
13. —— Maackii, *Brem.*
14. Erebia niphonica, *Jans.*
15. Mycalesis perdiccas, *Hew.*
16. —— gotama, *Moore.*
17. Ypthima evanescens, sp. n.
18. —— argus, *Butl.*
19. Apatura substituta, *Butl.*
20. Dichorragia nesimachus, *Fabr.*
21. Hestina japonica, *Feld.*
22. —— charonda, *Hew.*
23. Limenitis sibilla, *Ochs.*
24. Neptis ludmilla, *H.-Sch.*
25. —— Pryeri, *Butl.* (arboretorum, *Oberth.*).
26. —— alwina, *Brem.*
27. —— intermedia, *Pryer.*
28. Araschnia fallax, *Jans.*
29. —— burejana, *Brem.*
30. Pyrameis cardui, *Linn.*
31. —— indica, *Herbst.*
32. Vanessa angelica, *Cram.*
33. —— Pryeri, *Jans.*
34. —— hamigera, *Butl.*
35. Vanessa xanthomelas, *Denis.*
36. —— io, *Linn.*
37. —— antiopa, *Linn.*
38. —— glauconia, *Motsch.*
39. Argynnis sagana, *Dbl.*
40. —— paphioides, sp. n.
41. —— anadyomene, *Feld.*
42. —— lysippe, *Jans.*
43. —— japonica, *Mén.*
44. —— pallescens, *Butl.*
45. —— locuples, sp. n.
46. —— nerippe, *Feld.*
47. —— fortuna, *Jans.*
48. —— niphe, *Linn.*
49. Libythea lepita, *Moore.*
50. Curetis acuta, *Moore.*
51. Lampides bellotia, *Mén.*
52. Lycæna Pryeri, *Murr.*
53. —— ladonides, *De l'Orza*, (kasmira ?, *Moore*).
54. —— argia, *Mén.*
55. —— argus, *Denis.*
56. —— euphemus, *Herbst.*
57. Scolitantides hamada, *Druce.*
58. Niphanda fusca, *Brem.*
59. Chrysophanus timæus, *Cram.*
60. Thecla sæpestriata, *Hew.*
61. —— lutea, *Hew.*
62. —— japonica, *Murr.*
63. —— fasciata, *Jans.*
64. —— taxila, *Brem.*
65. —— stygiana, *Butl.*
66. —— mera, *Jans.*
67. —— attilia, *Brem.*
68. —— enthea, *Jans.*

69. Thecla arata, *Brem.*
70. Amblypodia asinarus, *Feld.* (japonica, *Murr.*).
71. —— turbata, sp. n.
72. Colias palæno, *Linn.*
73. —— poliographus, *Motsch.*
74. —— Elwesii, sp. n.
75. —— simoda, *De l'Orza.*
76. —— pallens, *Butl.*
77. —— subaurata, sp. n.
78. Terias Jægeri, *Mén.*
79. —— betheseba, *Jans.*
80. —— Mariesii, *Butl.*
81. —— anemone, *Feld.*
82. —— mandarina, *De l'Orza.*
83. Gonepteryx aspasia, *Mén.*
84. —— nipalensis, *Gray.*
85. Synchloe melete, *Mén.*
86. —— megamera, *Butl.*
87. —— crucivora, *Boisd.*
88. Euchloe scolymus, *Butl.*
89. Parnassius glacialis, *Butl.*
90. Papilio teredon, *Feld.*
91. —— asiaticus, *Mén.*
92. —— hippocrates, *Feld.*
93. —— xuthus, *Linn.*
94. Papilio nicconicolens, sp. n.
95. —— Maackii, *Brem.*
96. —— Dehaanii, *Feld.*
97. —— japonica, *Butl.*
98. —— macilentus, *Jans.* (scævola, *Oberth.*).
99. —— tractipennis, sp. n.
100. —— demetrius, *Cram.*
101. —— spathatus, sp. n.
102. —— Thunbergii, *Sieb.*
103. Hesperia japonica, *Murr.*
104. Pamphila pellucida, *Murr.*
105. —— guttata, *Brem.*
106. —— rikuchina, *Butl.*
107. —— ochracea, *Brem.*
108. —— sylvatica, *Brem.*
109. —— herculea, sp. n.
110. —— flava, *Murr.*
111. Pyrgus sinicus, *Butl.*
112. —— maculatus, *Brem.*
113. Daimio tethys, *Murr.*
114. —— Felderi, sp. n.
115. Astictopterus ornatus, *Brem.*
116. Thanaos montana, *Brem.*
117. —— rusticanus, *Butl.*
118. Antigonus vasava, *Moore.*

Descriptions of the new Species.

Neope niphonica, sp. n.

Allied to *N. Gaschkevitchii*, rather smaller and shorter in wing; above considerably darker, with orange, instead of white fringe. Primaries below yellower, all the markings thicker and darker, the discoidal markings more uniform, the third being less zigzag or 3-shaped: secondaries with the discal ocelli smaller and far more uniform in size; the base, abdominal area, subbasal spots, central belt, and external area filled in with blackish olivaceous; the external area washed with lilac; the pale band just in front of the ocelli spotted with brown and tinted with lilacine below the angle. Expanse of wings 2 inches 7–8 lines.

The natural position for this species is between *N. Gaschkevitchii* and *N. agrestis*. We have eight males and one female, which I have compared with twelve *N. Gaschkevitchii*, and find the differences constant.

Lethe consanguis, sp. n.

Allied to *L. Whitelyi*, similar on the upper surface, but differing below in the outer edge of the broad central belt of primaries being more transverse, obliquely excised on the costa, very slightly zigzag on the second median interspace, bordered externally with white as usual; three decreasing ocelli in a lilac nebula towards apex, as in typical *L. diana*: secondaries with the zones of the ocelli and the submarginal band silvery (or steel) blue instead of lilac, the third ocellus reduced to a mere point. Expanse of wings 2 inches 4 lines.

It is possible that this may prove to be a beautiful variety of *L. Whitelyi*; but it differs conspicuously from our examples of that species, particularly in the vivid coloration of the ocellus-zones and submarginal band below.

Ypthima evanescens, sp. n.

Above like *Y. lisandra*, below more like *Y. zodia*: wings below white, densely striated with short brown lines and crossed before the middle by two subparallel yellowish stripes, the outer one angulated on the secondaries; external border also regularly yellowish, but paler than the stripes: primaries with a large subapical yellow-zoned black ocellus with two silver pupils; secondaries with six very minute yellow-zoned black ocelli with single silver pupils; these ocelli are arranged as in *Y. stellera*. Expanse of wings 1 inch 5 lines.

One example.

Argynnis paphioides, sp. n.

Near to *A. paphia* of Europe, but considerably larger, the primaries more produced, the female always greenish above (but not so dark as the variety *A. valezina*), under surface with the silver bands and border of secondaries much more metallic. Expanse of wings, ♂ 3 inches, ♀ 3 inches 4 lines.

A long series of specimens.

Argynnis locuples, sp. n.

♂. Size of *A. vorax*, pattern and coloration of the upper surface similar, excepting that the spots of the discal series are more elongated, and the submarginal connected lunate spots of the secondaries are rather broader. Primaries below with silvery apical submarginal spots, as in *A. jainadeva*, the darker markings on the apical area cupreous brown with olivaceous margins, the discoidal markings smaller, otherwise as in *A. vorax*: secondaries below similar in pattern to *A. pallescens*, but the ground-colour more golden in tint, and the submarginal silver spots less sharply defined; the disk, between the series of ferruginous ocelloid spots and the green-bordered silver submarginal series, is clear buff-colour. Expanse of wings 2 inches 10 lines.

♀. Larger than the male, duller and greener above, with all the black spots larger. Below with eight additional subapical silver spots on the primaries, five of them forming a decreasing submarginal series, the ground-colour duller and more uniform in tint: secondaries with all the silver spots considerably larger, the third series well defined and continued to the submedian vein, so that there are five complete series; the submarginal series formed of broad black-bordered arched spots; the ground-colour rather deeper, the ocelloid ferruginous spots frequently larger than in the male, but always darker. Expanse of wings 2 inches 10 lines to 3 inches 3 lines.

A long series of specimens.

The natural position of this species will be between *A. vorax* and *A. pallescens*; it appears to represent *A. chloradippe* in Japan.

Colias Elwesii, sp. n.

♂. Above lemon-yellow, the basal three sevenths and costal border of primaries densely irrorated with greenish grey; basal fourth of costal margin ferruginous; apical area (from apical two fifths of costa to external third of third median branch) and a broad external border, sinuated in second median interspace and at external angle, black; a subapical series of irregular yellow spots, a large broad lunate spot on the border in the first median interspace and a small spot below it yellow; a large black discocellular spot: secondaries irrorated with grey; a submarginal series of large subconfluent sulphur-yellow spots, bounded internally towards the costa by a few blackish scales; apical border and three large spots at the extremities of the radial and second and third median branches black; fringe varied with rose-colour; a large bright orange spot at the end of the cell: body normal. Under surface lemon-yellow, the characters of the upper surface indistinctly traceable through the texture of the wing, costal margins and fringes rose-coloured: primaries with a diamond-shaped silver-centred black discocellular spot; three squamose blackish spots parallel to the outer margin on the median and interno-median interspaces: secondaries with an ochreous-bordered purple-edged silver spot at the end of the cell; a discal arched series of purplish-red dots commencing with an angular spot of the same colour upon the costa: body whitish, legs rosy. Expanse of wings 2 inches 8 lines.

♀. Above like the male, excepting that all the submarginal lemon-yellow spots of the secondaries are bounded internally by blackish scales, which, however, get less distinct towards the abdominal area; below with rather brighter primaries, the three discal spots larger, brown, and the series continued by two smaller brown spots or dots on the radial interspaces and two costal spots, the secondaries with a small additional silver-centred spot above the one at the end of the cell; otherwise exactly like the male. Expanse of wings 2 inches $5\frac{1}{2}$ lines.

Albino ♀. Above creamy white, the basal area and costal border of primaries and the secondaries bluish grey; the spots on the border smaller than in the male, the discocellular spot larger; the marginal spots of secondaries diffused and subconfluent, the first being confluent with the apical border; the submarginal spots only slightly paler than the ground-colour, smaller than in the ordinary form, the first two bounded internally by large black lunate spots, the others by a few blackish scales; orange spot very pale. Primaries below white, with greyish basal area, the discal series of spots completed, beginning in the interno-median and median interspaces with three decreasing triangular black spots, after which they are small and red-brown; apical area greenish sulphur-yellow, brighter at outer margin; costal margin and fringe rose-red: secondaries green, washed with yellow towards the base, fringe rose-red; markings as in the ordinary female. Expanse of wings 2 inches 8 lines.

This is a tolerably common species, allied to *C. simoda*, but differing constantly from that form in the greater length of the costal margin of the primaries, the larger pale submarginal spots, with less-defined internal limiting spots on the secondaries, the maculated character of the border on these wings, the noticeably paler colour of the under surface, the increased number of the discal spots on the under surface of the females, and the greater size of the albino females.

I have come to the conclusion that this species is constant (so far as *Colias* ever is so) to the characters above laid down, after examining nearly 200 specimens of the *Hyale* group from various parts of Japan. Mr. Elwes says (Trans. Ent. Soc. 1880, p. 144) "it would be most unlikely that *in such a genus** four species of one group should exist in Japan alone, or, rather, in *that very small part of Japan* from which collections have come." Can Mr. Elwes be speaking seriously when he makes this statement? Is it a fact that the collections received were obtained from so limited an area that it is "unlikely" that distinct allied species should come to hand? Are Hakodaté, Yokohama, Nikko, and Nagasaki localities so close together and so identical in their conditions of life that it is absurd to look for allied but distinct species in collections from these localities?

* Mr. Elwes does not explain this expression; and I fail to comprehend its meaning.

It appears to me that there must be sufficient variation of conditions in 260,000 square miles of insulated land, divided into three larger islands by intervening straits, and exhibiting considerable degrees of elevation, to render the existence of different species in the same group less a probability than a certainty.

That it does "require special training to appreciate" specific differences is a truism which no entomologist who has specially studied any branch of his science will be inclined to dispute; for that very reason it is unwise for any naturalist, when taking up the study of a branch of science comparatively new to him, to plunge at once into the most difficult genus in that branch, and criticise the work of all previous labourers in the same field.

Whilst referring to the paper by Mr. Elwes, it will save further trouble to call attention now to some observations of his on p. 141. Mr. Elwes says that I have "*described* no less than four supposed species and varieties nearly allied to this," meaning *C. erate*; and, as though to confirm this surprising statement, he inserts in brackets "see P. Z. S. 1880." Although not aware that I had described any species allied to *C. erate* from Candahar, either supposed species or variety, I took the trouble to look through the 'Proceedings of the Zoological Society of London' for 1880; but I could not find any descriptions of *Colias* by myself. It is a pity that Mr. Elwes did not give a reference to the page, as it might have tended to explain his meaning. Mr. Elwes then proceeds to say that he *entirely* fails to follow my distinctions, and goes on to prove it by declaring that what I call *C. erate* is like the specimens of that species from South Russia and the Punjaub, that what I call *C. helictha* differs from *C. hyale* just as Lederer says it does *, that what I call *C. sareptensis* is identical with *the form* of *Hyale* found all over Asia, from the Himalayas to Japan (specifying, however, *three forms* which have hitherto come only from Japan), and, lastly, that what I call *C. pallida* is just what Staudinger says it is, a white variety of *C. erate* ♀.

I need say no more respecting this paper on *Colias*; it possibly may not seriously affect the study of the genus, since most Lepidopterists will probably hold the same opinions now as before its publication; the only cause for regret is that Mr. Elwes did not pause before publishing that in haste of which it is possible he may, after more profound study, repent at leisure.

* Mr. Elwes repeats the obviously erroneous suggestion that *C. helictha* is a hybrid between two species not occurring in the same country.

Colias subaurata, sp. n.

♂. Above very similar in coloration and pattern to the preceding species, but with distinct depressed marginal triangular yellow spots, and the wings less irrorated with grey; the secondaries also without paler submarginal spots, but with a zigzag black line on and between the veins towards the apex; no distinct apical border, but six large marginal black spots. Below the wings are bright golden orange or very bright ochreous yellow, with the inner border of the primaries lemon-yellow; three large black discal spots (as in the preceding species), two blackish dots on the radial interspaces, and two brownish dots on the costa; a black discocellular spot, with a yellow pupil; costal margin and fringe rose-red: secondaries with costal margin and fringe as in the primaries; a discal arched series of indistinct plum-coloured dots, beginning on the costa with a spot of this colour; a silver spot at the end of the cell with plum-coloured margin and orange zone, and above it a similar but very minute and fusiform spot; venter somewhat whitish, legs rosy. Expanse of wings 2 inches 2 lines.

♀. Larger than the male; the basal area more densely irrorated with greenish grey: secondaries densely irrorated with greenish grey, the orange spot very large and dark; marginal black spots diffused inwardly, the first two confluent; a submarginal series of irregular yellow spots bounded internally by an arched series of heavy black lunules. Under surface exactly as in the male. Expanse of wings 2 inches 8 lines.

Albino ♀. Above with the ground-colour creamy white, the primaries bluish grey towards the base; marginal spots obsolete, otherwise as in the ordinary form: secondaries densely irrorated with grey, hardly greenish, the marginal black spots united into a border, the submarginal spots fairly regular, internally bounded by blackish spots, but only very distinctly towards the costa; orange spot rather paler than in the ordinary female. Primaries below with only the apical area and a suffusion over the discoidal area of the same golden ochreous colour as in the male; the rest of the primaries creamy white, but with the usual markings; costal margin and fringe red: secondaries as in the ordinary form, excepting that the discal dots are larger. Expanse of wings 2 inches 5 lines.

This is a fairly common species, which may be readily distinguished by the deep coloration of the under surface.

Papilio nicconicolens, sp. n.

Very near to *P. helenus*, but constantly differing in the creamy-yellow patch of secondaries being carried below the radial vein in the form of a large squamose spot, and in the submarginal lunules on the under surface of the same wings being far more arcuate. Expanse of wings 5 inches 3 lines.

Papilio tractipennis, sp. n.

♂. Intermediate in size between *P. macilentus* and *P. demetrius*; similar to the latter, from which it differs in its greater size, its more elongated wings, longer and broader tails, also in the greyer tints of the primaries, upon which the black outer border appears more prominently; below the primaries are distinctly paler and greyer, the markings upon the secondaries are brighter in colour, redder, and there is an abbreviated additional red fasciole, bounded below by an arcuate streak of blue scales, across the first median interspace. Expanse of wings 5 inches 2 lines.

♀. This is the *P. demetrius* of Gray (nec Cramer); but when fresh this sex is nearly as dark as the male, although browner in tint, and with two ocellated and several submarginal lunate red markings on the upper surface of the secondaries: as usual, it is broader in wing than the male, and the tails are shorter. Expanse of wings 5 inches.

A tolerably common form, which may possibly prove to be a seasonal variety of *P. macilentus*; but until this species can be reared, it must necessarily be separated as a distinct species. The examples of *P. macilentus* taken by Mr. Maries are much worn.

Papilio spathatus, sp. n.

Possibly a seasonal form of *P. alcinous*; the latter species, however, was not obtained in Niphon by Mr. Maries; he obtained shattered males and a single fine female in Yesso; it is therefore more probable that this is a local representative of *P. alcinous*. It differs in its considerably greater size, much longer and more spatulate tails, in the heavier black borders and veins on the female, in the much obscured red submarginal lunules on the upper surface of the male secondaries, and the broader and dingier submarginal curved spots on the female secondaries. Expanse of wings, ♂ 4 inches 1 line, ♀ 4 inches 10 lines.

This is a commoner species than *P. alcinous*, which (owing to the fact that Klug erroneously figures its female as that sex of his species) it generally represents in collections. *P. alcinous* ♀ agrees with the male in size and form.

In Yesso Mr. Maries caught the female of a species which in 1862 we received the male of from Hakodaté. It is allied to *P. mencius* of Felder (males of which Mr. Maries obtained at Kiukiang, China); but the wings are darker, the tails on the secondaries are more slender, the submarginal lunules are absent from the upper surface of the male secondaries, and are less arcuate and smaller upon the upper surface of the female. To this species I give the name of *P. hœmatostictus.*

Pamphila herculea, sp. n.

Allied to *P. sylvanus*, considerably larger; the male of a clearer, more ochraceous colour above, and on the under surface of a more uniformly tawny colour; the secondaries not yellowish, as in *P. sylvanus*; pattern similar. Expanse of wings 1 inch 7 lines.

♀. Above bronzy brown or chocolate-brown, with cupreous reflections: primaries with a yellow dot just above the basal third of submedian vein; a cuneiform spot filling the base of the first median interspace; a bifid spot at the end of the cell; a series of five quadrate spots, excised in front, crossing the disk obliquely from submedian to upper radial vein, and a trifid spot across the subcostal branches, halfway between the cell and the apex, buff: secondaries with an angular discal series of five ochreous spots. Wings below with the markings paler than above, the spots creamy whitish or pale bone-yellow; disk of primaries round the borders of the oblique series of spots olive-brown; external angle and outer border whity brown: secondaries bronzy olive-brown, the discal series consisting of six spots; anal angle broadly ochreous; outer border tinted with ochraceous; palpi white; body below bluish grey. Expanse of wings 1 inch 7½ lines.

One pair only was obtained.

Daimio Felderi, sp. n.

Dark brown, with white markings: primaries exactly as in *D. tethys*: secondaries crossed by a white belt, which passes through a nearly complete circular series of black spots; anal three fourths of fringe and four marginal spots white: posterior margins of abdominal segments white. Base of secondaries and body below bluish grey. Expanse of wings 1 inch 6 lines.

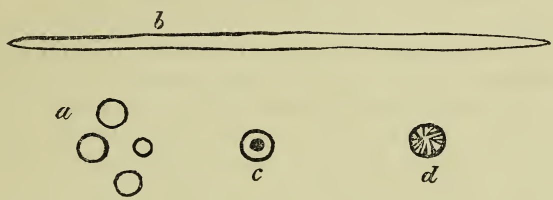
A tolerably common species; its position is between *D. tethys* and *D. sinica* of Felder; it appears to represent the latter in Japan, and differs from it in the smaller spots on the primaries, and in the black spots being visible upon the white belt of the secondaries.

XIII.—*Note on the Occurrence of Sponge-spicules in Chert from the Carboniferous Limestone of Ireland.* By Prof. W. J. Sollas, M.A., F.R.S.E., &c.

On studying the beautiful microphotographs of sections of chert figured in Prof. Hull's valuable paper "on the Nature and Origin of the Beds of Chert in the Upper Carboniferous Limestone of Ireland" *, it appeared to me that in some of these photographs traces of sponge-spicules could be seen. On communicating my opinion to Prof. Hull, he most obligingly sent me five of his mounted sections of chert for microscopical examination. For this act of kindness I now offer him my best thanks.

The results of my examination of the slices were, in the first place, to completely confirm his clear descriptions of the appearances presented by them, and, next, to establish the

Fig. 1.



Sections of sponge-spicules in Carboniferous chert: *a*, transverse; *b*, longitudinal; *c*, transverse, showing axial canal; *d*, showing radiately crystalline structure. (Magnified 50 diameters.)

truth of my supposed detection of sponge-spicules. The slides are numbered C 22 (fig. 4 in Prof. Hull's memoir), C 23, C 24, C 25 (fig. 1 in the memoir), and C. 41. In the first four a number of clear spaces with definite circular outlines (fig. 1, *a*) 0·003 inch in diam. were clearly visible, and also a number of long, straight, parallel-sided bands (*b*) of the same breadth as the diameter of the circles. The bands are longitudinal, the circles transverse, sections of sponge-spicules, and are exactly similar to those with which I am from long acquaintance familiar in the flint and chert of other localities.

The transverse sections frequently show a central dark spot (*c*), the remains of the axial canal; and in both directions of section a radiate crystalline structure (*d*), such as I have often observed and recently described in loose fossil spicules, is apparent with polarized light.

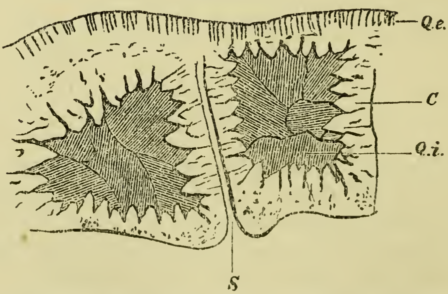
* Sci. Trans. Roy. Dublin Soc. vol. i. n. s., p. 71, pl. iii.

Of slices C 22 and C 23 it may be safely said that the chief determinable constituents are sponge-spicules; they make up the larger part of the chert.

Rhombohedra of dolomite, precisely similar to those described by Prof. Renard in his paper on the Carboniferous Phthanites*, are also to be seen in most of the sections. The presence of these crystals can readily be explained in accordance with the theory of the formation of flint lately advocated by me. It is well known that most limestones contain a trace of magnesian carbonate, probably in the form of dolomite. This is very much less soluble in acids than calcite, so that it is left as a residue on dissolving limestone in dilute hydrochloric acid. The silicic acid which dissolved and replaced the calcic carbonate would therefore act with greater difficulty on the dolomite, and, indeed, would in all probability have no action upon it at all; and so, while the mass of the limestone underwent silicification, the rhombohedra of dolomite would remain unaltered in the midst of the chert, just as we now find them.

That the formation of the chert continued, if it did not commence, some time subsequent to the formation of the limestone is proved by a curious fact observable in the section of coral shown in the centre of the section represented in fig. 1 of Prof. Hull's plate. Some of the vesicular spaces at the edge of this are completely lined by crystals of calcite (dog-tooth spar) which has not undergone silicification, while the interior of the spaces is occupied by crystalline grains of quartz (fig. 2).

Fig. 2.



Part of section of coral from chert (fig. 1, pl. iii. Hull's paper): *Q e*, external wall, consisting of radiating crystalline fibres of quartz; *S*, septum; *C*, calcite lining marginal vesicle; *Q i*, quartz within the vesicle. (× 60 diam.)

It is clear that the coral had been dead and exposed to the

* Bull. de l'Acad. roy. Belg. 2e sér. t. xlvi.

action of surrounding waters long enough for a deposit of calcite to be formed within the marginal vesicles before the infiltration of silica occurred.

Of the section of chert labelled C 41 I could make but little; it appeared to contain clastic granules of quartz.

XIV.—*Recent Dredging by the United-States Fish Commission off the South Coast of New England, with some Notice of the Crustacea obtained.* By S. I. Smith.

The United-States Commission of Fish and Fisheries, under the direction of the Commissioner, Professor Baird, with headquarters at Newport, Rhode Island, has had increased facilities for scientific work the past season, and has added even more than in past years to the knowledge of our marine fauna. The new steamer 'Fish Hawk,' of 480 tons, built for the work of the Commission, and under the command of Lieut. Tanner, U.S.N., is specially fitted for scientific work, and was employed a large part of the season in trawling, dredging, and in making temperature observations. The investigation of the invertebrate fauna, as in previous years, was carried on by a party under the general direction of Professor Verrill, of Yale College. Large collections were made in the shallower waters along the coast and also on the shores; but the most interesting results were obtained from a series of trawlings and dredgings made in September and the first week in October, on three trips 75 to 100 miles off the coast, in the region known as the Block Island Soundings. A general account of these trips is given by Prof. Verrill in the 'American Journal of Science' for November (vol. xx. pp. 390–403), and need not be repeated here, further than that the region examined is in north lat. 39° 46′ to 40° 06′, west long. 70° 22′ to 71° 10′, that on each trip the dredging and trawling occupied less than a day's time, and that twenty-two hauls of the dredge and trawl were made from depths varying from 64 to about 500 fathoms. Wire rope was very advantageously employed in all the dredging and trawling. At one station, 86 fathoms, the bottom was covered with shells and sponges; but at all the other stations it was composed of fine sand and mud.

The collections have not been fully examined; and this is specially true of the collections from the deepest water which were made on the last trip. But the wonderful richness of the fauna in mollusks and echinoderms has been shown by Professor Verrill in the paper already referred to; and it is certainly not less remarkable as regards the crustaceans. The richness of the fauna in both species and individuals would never have been suspected by one accustomed only to the meagre fauna of the shallow waters of the south coast of New England.

In regard to the mollusks and echinoderms, it is here sufficient to quote a few sentences from Professor Verrill's article. He says:—"Of Mollusca about 175 species were taken. Of these, 120 species were not before known to occur on the southern coast of New England; about 65 are additions to the American fauna; of these about 30 are apparently undescribed. The known species now added to our fauna have mostly been described by G. O. Sars, Jeffreys, and others from the deep waters of the European coast and the Mediterranean." "The Starfishes and Ophiurans were exceedingly abundant and beautiful at all the stations; and many species not known previously on our coast were taken, several of which appear to be undescribed, while others were known only from Northern Europe or from the deep waters off Florida. Many of the species have only recently been obtained from the northern fishing-banks off Nova Scotia. One new species of *Archaster* (*A. americanus*) was particularly abundant, several thousands of specimens having been taken; but the two largest and most beautiful species of this genus were *Archaster Agassizi* (new) and *A. Floræ*. Of *Odontaster hispidus* over 100 were taken." There are thirty-two species in the partial list of echinoderms given, four of which are described as new.

A preliminary notice of the Crustacea obtained from this interesting region is now in type for the 'Proceedings of the National Museum' for 1880 (pp. 413–452); and I here give only a very brief statement of the most interesting results there brought out, with full descriptions of the new forms.

Among the Brachyura were *Hyas coarctata*, *Cancer borealis*, and *Geryon quinquedens*, which were known from further north; but with these there were *Collodes depressus*, *Euprognatha rastellifera*, *Bathynectes longispina*, and *Acanthocarpus Alexandri*, species previously known only from the Straits of Florida. There were also new species of *Ethusa* and *Lambrus*, genera quite new to our waters. The *Euprognatha* occurred in the greatest abundance at nearly every station, many thousands of specimens often being taken at a single haul.

Among the Anomura occurred *Homola barbata* and *Latreillia elegans* (which represent families heretofore unknown on this side of the Atlantic), a beautiful species of *Lyreidus*, De

Haan (a genus before known only from the North Pacific), and a species of *Munida*. These were associated with *Eupagurus bernhardus*, *E. Kröyeri*, and the remarkable *Parapagurus pilosimanus*, which were before known from the north. But the most interesting Anomura were two species of a new genus (*Hemipagurus*), allied to the little-known genus *Spiropagurus*, Stimpson, but differing conspicuously in the form and position of the single sexual appendage of the last thoracic somite of the male, which arises from the coxa of the *right* side, while in *Spiropagurus* it arises from the *left* side. Both the species of *Hemipagurus* inhabit cases formed by a colony of *Epizoanthus* or by an individual of a species of *Adamsia*.

The unsymmetrical development of the external sexual organs of the males of this genus is accompanied by a most remarkable difference in the corresponding internal organs. The abdominal viscera are not sufficiently well preserved in the ordinary alcoholic specimens for a full anatomical and histological investigation; but the following observations, though incomplete, are so novel and interesting that I insert them here. The right testis and vas deferens are much larger than the left. The lower part of the right vas deferens, in all the adults examined, is much more dilated than the left, and is filled (as is also the external part of the duct) with very large spermatophores of peculiar form. The left vas deferens is slender, much as in *Eupagurus bernhardus*, terminates in a small opening in the left coxa of the last thoracic somite, as in ordinary Paguroids, and contains spermatophores somewhat similar in form and size to those of *Eupagurus bernhardus*. In alcoholic specimens of the larger and more abundant of the two species, the spermatophores from the left vas deferens are approximately 0·16 millim. long and 0·035 millim. broad, with a slender neck about a third of the entire length, and a very thin and delicate lamella for a base. The spermatophores from the right vas deferens are over 2 millims. in total length; the body itself is oval, approximately 0·40 millim. long and a third as broad; at one end it terminates in a very long and slender process, two or three times as long as the body; at the other end there is a similar but slightly stouter process, a little longer than the body, and expanding at its tip into a broad and very delicate lamella, approximately 0·35 millim. long by 0·20 millim. broad. The contents of the two kinds of spermatophores are, of course, not in a condition to show the structure of the spermatozoa; but they present a similar appearance in each case, and are apparently of about the same size.

The most interesting of the Macrura is, perhaps, a new species of *Nephropsis*, very closely allied to *N. Stewarti*, Wood-Mason, heretofore the only known species, which was described from a single specimen dredged in the Bay of Bengal and wanting the great claws. These claws, in our specimens, are clothed with very long soft hair, and are very different from the great claws of *Nephrops*, though the genus is very closely allied to *Nephrops*, as pointed out by Wood-Mason. The number and arrangement of the branchiæ, not noticed in the description of *N. Stewarti*, are the same as in *Nephrops*. There were also new species of *Arctus*, *Axius*, *Pontophilus*, *Bythocaris*, *Pandalus*, and *Penœus*, and with these the following arctic species—*Pontophilus norvegicus*, *Pandalus propinquus*, *Hippolyte securifrons*, and *Sergestes arcticus*, the last species being common in 300 to 500 fathoms.

Among the Schizopoda were three arctic species, *Thysanopoda norvegica*, *Pseudomma roseum*, and *Boreomysis arctica*, the last heretofore known to America only from Greenland.

The only Stomatopod was a new species of *Lysiosquilla*, which appears to be closely allied to *L. spinosa*, from the Indian Ocean and New Zealand, or at least much more closely allied to this than to any other species described in Mr. Miers's recent review of the Squillidæ.

Few species of Amphipoda were found; but the arctic species, *Stegocephalus ampulla*, *Haploops setosa*, and *Epimeria loricata*, G. O. Sars, occurred, the last in abundance.

Among the Isopoda there were four species previously known only from further north on our coast, and *Mounopsis typica*, a deep-water species known from our northern coast, Greenland, and Northern Europe. There were besides several species not determined.

Fifty species of Malacostraca are enumerated in the preliminary notice above referred to; and of these fourteen are described as new and three others are indicated as probably new, forty-three are first recorded as belonging to the New-England fauna south of Cape Cod, twenty-eight are new to the whole fauna from Cape Hatteras to Northern Labrador, and twenty-one are new to America including Greenland. Of the forty-three species new to the Southern New-England fauna, fifteen are now known also from the New-England fauna north of Cape Cod; and of the remaining twenty-eight, four were already known from the Straits of Florida, three from Greenland and Northern Europe, and two from the Mediterranean. It should be added that two of the species, the *Lyreidus* and the *Nephropsis*, belong to genera heretofore known only from the Pacific region, and each represented there by a single species, while a third species, the *Lysiosquilla*, has its nearest known ally in a species from the same region.

New Haven, Conn., U. S. A.,
Dec. 29, 1880.

XV.—*Contributions towards a General History of the Marine Polyzoa.* By the Rev. Thomas Hincks, B.A., F.R.S.

[Continued from vol. vi. p. 384.]

[Plates VIII., IX., & X.]

IV. FOREIGN MEMBRANIPORINA (second series).

a. With a membranous front wall.

Membranipora coronata, n. sp.
(Pl. X. fig. 1.)

Zoœcia lozenge-shaped, contiguous; area occupying the whole front, with a membranous covering; margin not much elevated, except round the oral extremity, where it rises into a hood-like screen, projecting slightly over the area and hollowed out in front into an arch; inner surface of the cell-wall very strongly crenated and granulated; immediately above each zoœcium an immersed *avicularium* with acute mandible, placed transversely. *Oœcium* (?). *Zoarium* white and shining.

Loc. Singapore or the Philippines, on coral (*Miss Jelly*).

The striking features of this pretty species are the crowning avicularium, the very marked crenation of the border of the cells, and the glossy whiteness of the whole zoarium.

Membranipora terrifica, n. sp.
(Pl. VIII. fig. 5.)

Zoœcia large, somewhat pyriform, arched above, widest in the middle, narrowing off below the area; area broad below, slightly contracted towards the top, with a membranous covering, occupying about two thirds of the front of the cell; margin not much elevated, thin, smooth; the wall of the cell below the area dense, uneven, punctured; placed transversely along the whole of the lower margin of the aperture, and projecting prominently on the subjacent space, a gigantic *avicularium*, with long, narrow, curved beak, the basal portion much expanded, with an angular projection on each side in the line of the hinge; mandible (probably) slender and setiform.

Loc. Straits of Magellan, on *Eschara flabellaris*, Busk (*Miss Gatty*).

Membranipora rubida, n. sp.
(Pl. VIII. fig. 6.)

Zoœcia somewhat pyriform, arched and expanded above, below the area narrowing rather abruptly downwards; area suborbicular, the covering wholly membranous, occupying about three fourths of the front of the cell; margin much raised round the sides and upper portion of the cell, thin, smooth, two spines on each side of the orifice, the foremost pair very tall and stout; zoœcium prolonged slightly below the area, and on this portion is situated an *avicularium* borne on the summit of a stout and rather tall peduncle, from the lower part of which two spines often project, mandible acute, directed downwards; sometimes replaced by a linguiform avicularium, slightly pedunculate, placed transversely. *Zoarium* of a reddish-brown colour.

Loc. Australia, on stone (*Miss Gatty*).

The prolongation of the cell below the area is often small and inconspicuous; but its position is indicated by the stalked avicularium which is always placed upon it. The peduncle of this appendage, which is of remarkable length, seems to consist of two parts—a short tubular base, which frequently bears two spinous processes, and is permanently attached to the cell, and a much longer cylindrical stem, on which the avicularium is supported; the latter is easily detached, and seems to be jointed in some way or other to the fixed basal portion. The structure is interesting, as showing a modification in the direction of the higher articulate forms.

Membranipora bicolor, n. sp.
(Pl. IX. fig. 1.)

Zoœcia oblong, narrow, alternate, very regularly disposed in lines, the whole front filled in by a membranous wall, at the very top of which is the opercular valve; margin thin and smooth; the zoœcia in each line separated by elongate spaces, usually rather less than the cell in length, which are covered in by a white calcareous roofing, terminating at one extremity in an arch, with a somewhat thickened rim, which incloses the orifice of the cell below, and at the other more or less hollowed out, the depression extending to the base of the cell above. No spines or *avicularia*.

Loc. West Australia, spreading over weed (*Miss Jelly*).

The elongate calcareous boxes interposed between the cells in this species might naturally be taken for oœcia; but they are closed in at the end by a calcareous wall, in which there seems to be no opening beyond some minute perforations. They have probably, therefore, some other significance; but what it may be I am unable at present to determine. The zoœcia are really of a slender, elongate-oval shape, though they sometimes appear quadrangular. The membranous front wall extends to the top of the hollow or depression in the neighbouring interspace, and lies quite on a level with the rim of the margins.

Membranipora bellula, n. sp.
(Pl. VIII. figs. 4, 4*a*, 4*b*.)

Zoœcia pyriform, rounded and expanded above, and narrowing off to the base; area occupying about half the length of the cell, wholly filled in with membrane, subelliptical, broad below and narrowing very slightly upwards to the top, where the semicircular orifice is placed, flanked on each side by two tall erect spines; on the lower margin a single, much-branched spine, which spreads over the aperture, forming an antler-like operculum; sometimes a very long corneous spine, springing from a raised socket, a little below the inferior margin; portion of the cell below the area, which is sometimes a good deal elongated, smooth and shining, and covered with numerous delicate spinules. *Oœcia* none.

Var. *a* (*bicornis*). With two opercular spines on the lower margin, of small size and slightly branched, placed one on each side of a short, sharply pointed central mucro rising from a prominent boss; a single spine only on each side of the orifice; no spinules or horny appendages; surface smooth, white, and very polished.

Var. β (*multicornis*). Opercular spines 3–5, placed closely together, their numerous dichotomous branchlets combining to form a beautiful protective shield, which extends to the base of the oral valve.

Loc. Australia, normal and var. *multicornis*; Ceylon, var. *bicornis*; Madagascar (*Miss Jelly*); St. Vincent, Cape-Verd Islands (*Miss Gatty*). *M. bellula* always occurs creeping over weed, and frequently runs out into narrow strap-like segments.

This is an exquisite species, which seems to be far from uncommon in various parts of the world; and it is difficult to understand how it is that it has remained so long undescribed. I cannot recollect, however, to have met with any published account of it, although it has been known to collectors under a manuscript name. It is a species which varies much in appearance, the changes being chiefly due to the presence or absence of the spinous appendages, and especially to the modification of the opercular spine. The principal varieties have already been noticed. In some cases the tall corneous spine rising from a distinct socket, which is so characteristic of *M. pilosa* (from which the present form is probably derived), makes its appearance; in others the zoarium bristles with immense numbers of slender spinules; in others, again, it has neither seta nor spinule. In a curious form from Madagascar the edges of the narrow segments into which the zoarium divides are fringed by very tall and slender setæ, frequently placed in pairs, whilst there is also a profusion of the suboral appendages. This form presents a very marked contrast to the extremely simple and elegant variety (*bicornis*) from Ceylon. The same variability in the spinous armature is characteristic of *M. pilosa*.

b. With a calcareous lamina.

Membranipora patula, n. sp.
(Pl. IX. fig. 4.)

Zoœcia short, narrowed above and broadly expanded below, the upper extremity of the cell much raised, the lower depressed; margin well raised, narrow, sharp, minutely granulated; aperture arched above, the lower margin slightly curved outwards, occupying fully three fourths of the length of the area, the lower fourth filled in by a strongly granulated, calcareous lamina, which is continued for a short distance up each side; on the upper margin four very stout cylindrical spines, two towards each side, which are articulated by corneous joints; projecting from the centre of the back of the cell, some way below the margin, an *avicularium* with pointed mandible, directed straight outwards. *Oœcium* (?).

Loc. California (*Miss Jelly*).

Membranipora setigera, n. sp.
(Pl. VIII. fig. 3.)

Zoœcia large, ovate; area occupying the whole front of the cell, the lower two thirds covered in by a shining calcareous lamina, minutely pitted over; aperture arched above, lower margin straight, closed by a rather stout membranous wall, at the upper extremity of which is the orifice; margin not much raised, granulated; a row of 6–8 tall spines surrounding the upper extremity of the area. *Avicularia* none. *Oœcium* (?).

Loc. Australia, investing *Serpula* (*Miss Gatty*).

This species belongs to the same section of the genus as our British *M. Rosselii* and *M. trifolium*. Its spines are a conspicuous character, the zoarium literally bristling with them. The surface is flat and somewhat glistening.

Membranipora spinosa, Quoy & Gaimard.

Flustra spinosa, Q. & G., Voy. de l'Astrolabe.
Membranipora ciliata, MacGillivray, Trans. Roy. Soc. Victoria, 1868.
Membranipora spinosa, Busk, Polyzoa of Kerguelen Island.

Busk identifies a form from Kerguelen Island with the

Flustra spinosa of Quoy & Gaimard; and from the figure which he gives it would seem to be the same as the *M. ciliata* of MacGillivray, an Australian species. If he is correct in his identification, the latter name must give place to that of Quoy and Gaimard.

The species has occurred in the following localities:—Kerguelen Island (*Mr. Eaton*); Australia (*MacGillivray*); Arabian Sea, between Bombay and Aden, lat. about 15° N., long. about 65° E. (*W. Oates*).

Another *Membranipora spinosa* has been described by D'Orbigny (Voy. dans l'Amér. Mérid. vol. v. 4e partie), which bears a close resemblance to *M. spinifera*, Johnston, but is apparently destitute of avicularia. It is furnished with about 10 spines on each side of the cell.

Membranipora permunita, n. sp.
(Pl. X. fig. 2.)

Zoœcia arched above, expanding very slightly towards the centre, and then narrowing off more or less to the base, which is subtruncate; area occupying the whole of the front of the cell, the lower two thirds filled in by a strong, thickly-granulated, calcareous lamina; aperture arched above, lower margin straight, higher than broad, margin scarcely elevated, very finely beaded; scattered amongst the zoœcia elongate, narrow-oval cells, the lower part of which is occupied by an *avicularium*, depressed at the base, the beak much raised, turned obliquely to one side, somewhat curved and pointed; mandible slender, edged on each side by a horny expansion; upper portion of avicularian cell hollow and open. *Oœcia* rounded, closely united to the lamina of the cell above, with a raised rib round the front, inclosing a minutely granulated space.

Loc. Off Curtis Island, Bass's Straits, common on shell (*Capt. W. H. Cawne Warren*).

This species occurs in a very interesting collection of Polyzoa made by Capt. Warren, of the ship 'Bedfordshire,' and presented by him to the Liverpool Free Museum. The committee of the Museum, at the instance of its very able and energetic curator, Mr. Moore, have entrusted the collection to me for examination; and I hope to describe and figure a number of new forms from it in subsequent papers.

M. permunita is interesting as being one of the few recent species belonging to the present section of the genus which are furnished with an avicularium of the elongate type placed on a well-developed cell-area. A very similar appendage occurs on *M. curvirostris*, mihi; and it is not uncommon amongst the species with a membranous front wall.

Membranipora (*Caleschara*) *denticulata*, MacGillivray*.
(Pl. VIII. fig. 2.)

Zoarium foliaceous, with the cells in two layers placed back to back, or incrusting. *Zoœcia* arched above, widening about the middle, and contracted below; margin smooth, sometimes traversed by a brown line, inner side of the cell-wall granular; area occupying the whole front of the cell, the lower one third filled in by a granulated calcareous plate; a transparent membranous wall extending over the entire area, including the calcareous plate, the oral valve being placed at the very top of it; from the centre of the upper edge of the lamina rises a broad calcareous process (also granulated), which extends to about one third the length of the aperture from the top, where it sends off two lateral branches to the wall of the cell, forming in this way a foramen on each side, the inner edges of which are denticulate; the upper margin of the process is slightly thickened, and shuts off a semicircular space above, corresponding with the operculum in the true front wall; at the bottom of each cell one or sometimes two rather large smooth nodules. *Oœcium* wide, little projecting, incorporated with the cell above, both the ovicelligerous cell and the one above it of unusual size (*MacG.*).

Loc. Victoria (*MacGillivray*): off Curtis Island, Bass's Straits, on shell, forming a brown subcircular patch (*Capt. Cawne Warren*).

MacGillivray places this species among the Escharidæ (Busk), simply, it would seem, on the ground of its erect habit. It has, in truth, no real affinity with this family as constituted by Busk. The depressed area, the elevated margins, and the membranous front wall show that its place is amongst the Membraniporidæ. Nor is there any sufficient ground, in my judgment, for referring it to a new genus. The peculiarity on which MacGillivray founds his *Caleschara* ("front calcareous, except a small part anteriorly, which is membranous") is, I believe, quite insignificant. I venture to think that he has misinterpreted the structure of the zoœcium, probably owing to the imperfect condition of the specimens which came under his notice. The "front" of his description is not the true front wall of the cell, but merely a calcareous upgrowth from the edge of the lamina (strictly

* 'Prodromus of the Zoology of Victoria,' decade v., by Fred. M'Coy, F.R.S.; 'Polyzoa,' by P. H. MacGillivray, p. 45, pl. xlviii. fig. 8.

comparable with the "serrated denticle," similarly placed in *Membranipora* (*Biflustra*) *delicatula*, Busk); and the membranous portion at the upper extremity is only occasional, and merely denotes imperfect development. That *the true upper wall of the zoœcium* is the membrane which closes in the whole of the area is evident from the course of development and from the fact that it bears the oral valve. In the younger zoœcia the laminar process is either wholly wanting or very imperfectly developed, whilst the membranous wall, furnished with the semicircular orifice for the egress of the polypide, occupies the whole of the opening *at a considerable distance above the lamina.*

The real peculiarity of this form is that the membrane incloses the granular plate and its process; but this, however curious, is hardly a generic character. The same thing occurs in a less degree in *M. nitens*, mihi. As to the habit of growth, MacGillivray's figure represents a small erect and foliated specimen; the one from Bass's Straits is wholly crustaceous. Another which I have examined grows round a stem of seaweed, and the free edges meeting on one side of it come together and unite; and in any further growth at this point there would be a bilaminate structure, and the zoarium would become erect and detached; but it would be none the less a *Membranipora.* The large nodules at the base of the cells, which were present in the specimen I have figured, materially change the general appearance of the species.

Membranipora cervicornis, Busk*.
(Pl. VIII. fig. 1, and Pl. X. fig. 3.)

Zoœcia oval; margin much raised round the upper part of the cell, forming a very thin wall, which also extends for some distance down the sides; area occupying the whole of the front, about a third of it filled in by a smooth and shining calcareous lamina, which is carried up for some distance on

* There has been some doubt whether the *M. cervicornis*, Busk (Cat. pt. 1, pl. c. fig. 3), is identical with the form described by MacGillivray under this name. Busk's figure does not show the detail of the zoœcium very clearly; but the branching spines, as he represents them, are certainly different from the similar appendages as given by MacGillivray. They are massive and spreading, and bend in over the area, the branches "meeting and inosculating;" whereas in the other form they are erect and comparatively slender, and show no tendency to unite across the cell. The colour also of Busk's species is said to be "purplish;" that of the Australian species white or brownish. Amongst Capt. Warren's dredgings, however, from Bass's Straits, I have met with specimens undoubtedly referable to MacGillivray's species, in which the spines are somewhat more massive, and occasionally meet and (apparently) unite across the cell; they are also of a deep purplish colour.

each side; aperture flattened above, narrowing downward, rounded at the lower extremity (very much in the form of a heraldic shield), surrounded by a slightly thickened rim; at the top of the cell four spines, placed two on each side, the foremost pair stout, suberect, and branched, like a stag's horn, the upper tall, slender, and slightly forked; between them a raised *avicularium* with pointed mandible, placed transversely on the margin of the cell, or projecting straight outwards from the back; frequently a large raised *avicularium* at the bottom of the cell. *Oœcium* very shallow, galeriform, smooth, the oral surface much sloped, so as to expose the opening; a raised line arching across the front a short distance above the opening, inclosing a narrow subhyaline belt; an avicularium on the summit, placed transversely; two spines in front of the ovicell, and two at the sides (Plate VIII. fig. 1). *Zoarium* white or brownish, or of a rather deep purplish colour.

Var. *a*. *Oœcium* much deeper (less shallow), almost subquadrate, the oral surface not sloped; a raised rib in front inclosing a subtriangular space; one or two avicularia at the back (Pl. X. fig. 3).

Loc. Victoria (*MacGillivray*); var. *a*, off Curtis Island, Bass's Straits (*Capt. Cawne Warren*).

I have thought it desirable to give a detailed description of this species, as MacGillivray has contented himself with a very brief diagnosis. Busk's account of his *M. cervicornis* is almost equally brief; and between the two there is some difficulty in deciding with any certainty as to the identity or otherwise of the two forms.

The differences in the oœcium are striking and curious; but they can only be regarded as varietal. The spines are articulated to a fixed tubular base, and are easily detached; in their absence it is somewhat difficult at first sight to recognize the species.

Note on *Membranipora transversa*, Hincks.

When I described this form ('Annals,' July 1880) I was not aware that Mr. Hutton had been before me. I had not then seen his paper in the 'Proceedings of the Royal Society of Tasmania' for 1877 (published in 1878), in which he has characterized it as *M. cincta*. Of course the name *transversa* must be cancelled; and I can only hope that it may drop out of sight and give no further trouble.

In a paper presented to the Royal Society of Victoria early in 1880 Mr. MacGillivray has given a fuller account of the same species, and proposes to refer it to a new genus, which he names *Diplopora*, and of which the distinctive characters seem to be that the zoœcium is divided into two parts, and that "a narrow transverse portion" of the front cell-wall, "a little distance behind the mouth and in front of the elevated part," is deficient in calcareous matter and entirely membranous. On reexamining my specimens I find that a membranous wall closes in the whole of the aperture, bearing the oral valve at the upper extremity, and extending almost to the top of the elevated portion of the cell. Beneath the oral valve is an elliptical orifice with calcareous margin filled in with membrane and having a circular opening in the centre; from the edge of this inner orifice a calcareous wall passes down to a fissure extending transversely across the cell, and probably marking the termination of the true zoœcium. Below the fissure is the wall of the elevated part of the cell, which is a strong box. Towards the base of this wall a tubular process projects into the fissure, probably forming a communication between the box and it. The precise significance of this structure can only be determined by an examination of living specimens; but it seems to form a good basis for a new generic group.

One curious peculiarity of this species should be noted. The colonies, which always seem to encircle the stems of certain algæ, commence with a (transverse) row of elongated, narrow, quadrangular cells, having the front entirely closed in with membrane, destitute of orifice, and of all the characteristic structure of the adult; this row is followed by a second, in which the cells resemble generally those in the first, but are much shorter; and from these the normal zoœcia originate.

Family **Microporidæ.**

Genus Vincularia (part), Defrance.

Vincularia abyssicola, Smitt.
(Pl. X. fig. 4.)

This form I had figured from a specimen incrusting a small fragment of coral, as (probably) a new species of *Setosella*; and only ascertained subsequently that it was identical with *Vincularia abyssicola* of Smitt. I mention this to show how essentially Membraniporidan the zoœcial character of this generic type is; in its incrusting state it is impossible to distinguish the present species from *Setosella*. Whether its peculiar habit of growth in the adult state (the zoœcia are arranged so as to form erect, cylindrical stems like those of *Cellaria*, but unjointed) entitles it to generic rank is a question to which different answers may be given; but *we indicate* *its true natural affinities* (and this is the important point) by ranking it in the family of the Microporidæ.

Vincularia ornata, Busk, and *V. neozelanica*, Busk, are true Membraniporidæ.

I have engraved the figure of *V. abyssicola*, as it shows a finer development of the remarkable vibracula than Smitt's. These appendages exhibit a very interesting structure, being edged for a considerable portion of their length along both sides by a rather broad membranous expansion.

Loc. Off Cojima, Cuba, 450 fathoms, on *Retepora*; Florida, 68 fathoms, on *Nullipora* (Pourtales); on coral from Singapore or the Philippines (*Miss Jelly*).

V. FOREIGN CHEILOSTOMATA. (Miscellaneous.)

Family **Epicaulidiidæ**.

Epicaulidium, n. gen.

Gen. char.—Zoarium calcareous, composed of a creeping base and erect stems, made up of internodes linked together at their extremities by corneous joints, on which the zoœcia are borne in companies. *Zoœcia* erect, clavate, with a small, oblique, subterminal orifice, several united together longitudinally, so as to form a cluster; the clusters opposite, free, except at the base, where they are attached by corneous joints to the internodes.

Epicaulidium pulchrum, n. sp.
(Pl. X. fig. 5.)

Stem composed of jointed internodes of about equal length, which are white, expanding gradually from the base upwards to a point a short distance below the top, where there is a slight protuberance on each side, surmounted by a circular orifice, from which the corneous joint supporting the cluster of cells originates; above the projections the internode narrows and continues cylindrical to the top; a number of small tubules immersed in the cells, which show as disks on the surface and give it a speckled appearance; no branching. *Zoœcia* in triplets, united through their whole length, the central one compressed, narrow, pointed below, slightly wider above, orifice oval, oblique, with a thin slightly raised margin, facing towards the base of the stem (downwards); two lateral cells subclavate, expanded above, narrowed and pointed at the base, orifice as in central cell, except that there is a small spine in the centre of the upper margin; surface smooth and shining; the lateral cells attached by the dorsal surface to the sides of the central, orifice facing sideways, with a slight turn upwards; the triplets also speckled, but less strongly and constantly than the stem; form of the triplets subcordate. *Oœcia* (?).

Loc. Jamaica, creeping over an alga (*Miss Jelly*).

Amongst the taller stems occur others consisting of a very short and slender internode attached by a corneous joint to the creeping base, and bearing on its summit a single triplet. In these cases growth seems to proceed no further. The *primary internode* of the ordinary stem is jointed to the creeping fibre, and is sometimes normal and sometimes altogether destitute of cells.

Family **Bicellariidæ.**

Diachoris, Busk.

Diachoris bilaminata, n. sp. (Pl. VIII. figs. 7, 7 *a*).

Zoarium (probably) erect, composed of two layers of cells placed back to back; connecting tubes six, very short. *Zoœcia* large, elongate, boat-shaped, suberect, placed close together and overlapping considerably; margin running out into a short spinous process on each side of the orifice; aperture occupying the whole front; orifice terminal; oral valve arched above, with a straight lower margin; at a short distance below the top on one side an articulated avicularium (often wanting), slender, rather compressed, the beak long and flat above, bent slightly and abruptly at the extremity; mandible very slender and sharply pointed. *Oœcia* (?).

Loc. New Zealand (*Miss Jelly*).

This diagnosis is founded on a fragment; and I can therefore give no account of the size or mode of growth. The zoœcia have a strongly marked character, and differ widely from those of any form with which I am acquainted. The layers are closely united, and constitute a very compact bilaminate zoarium. A striking point is the degree in which the zoœcia overlap one another, each cell originating a good way down on the dorsal surface of the one below it.

The affinity between *Diachoris* and *Beania* and *Bugula* is of the closest kind; between the present genus and the last named there is indeed but a single point of difference that is at all constant, the disjunct condition of the cells; and this can hardly be regarded as specially significant*.

The following species of *Diachoris* have been described:— *D. Crotali*, Busk, Bass's Straits; *D. magellanica*, Busk (=*D.*

* I quite agree with Mr. Waters that "the genus *Diachoris* can only be looked upon as a provisional one" ("Bryozoa of Bay of Naples," 'Annals,' Feb. 1879, p. 120).

Buskei, Heller), Straits of Magellan, New Zealand, Mediterranean; *D. inermis*, Busk, New Zealand, Straits of Magellan; *D. costata*, Busk, Kerguelen Island, Australia; *D. spinigera*, Australia; *D. hirtissima*, Heller (= *Chaunosia hirtissima*, Busk), Adriatic, Cape of Good Hope; *D. armata*, Heller, Adriatic; *D. patellaria*, Moll (= *D. simplex*, Heller, and *Mollia patellaria*, Smitt—generically distinct), Adriatic; *D. Buskiana*, Hutton, New Zealand.

Family **Myriozoidæ** (part), Smitt.

Schizoporella, Hincks.

Schizoporella argentea, n. sp. (Pl. IX. figs. 6, 6 *a*.)

Zoœcia ovate, irregularly disposed, convex, strongly sutured, separated by inconspicuous lines, very distinctly and beautifully granulated over the entire surface, punctured round the margin, greyish white, lustrous; orifice suborbicular, produced below into a pointed sinus; peristome not raised; along one side of it a large mound-like elevation, rising to a point above, on the inner face of which is an erect *avicularium*, with acute mandible directed upwards; on the opposite side, just beyond the sinus, a short spinous process; on the upper margin two or three spines; in many cases the oral avicularium, instead of being erect and close upon the margin, is turned downwards and outwards, is much elongated, and stretches down about half the length of the cell. *Oœcia* rounded, thickly granulated and punctured. *Zoarium* of very delicate texture, greyish white, silvery.

Loc. Africa, on coral (*Miss Jelly*)

Schizoporella linearis, Hassall, form *quincuncialis*. (Pl. IX. fig. 3.)

Zoœcia ovate, occasionally lozenge-shaped, moderately convex, separated by lines, quincuncially arranged; surface bright and silvery, thickly punctured; orifice suborbicular, with a shallow pointed sinus on the lower margin, a ridge-like callosity placed longitudinally immediately below the sinus; at each side of the orifice, usually almost close to the top of the cell, a mound-like rising, bearing a small *avicularium*; mandible acute, generally directed upwards. *Oœcium* (?).

Loc. Ceylon (*Miss Jelly*).

In general appearance this variety is very unlike the well-known *S. linearis*. Its zoœcia exhibit none of the depression of surface and definite linear arrangement which are so characteristic of the normal form; they are ovate, convex, and quincuncially disposed. But, on the other hand, the zoœcium agrees with that of the normal form in the form of the orifice, and in having a small, raised, and pointed avicularium on each side of it. These appendages, indeed, are placed somewhat higher up than is usual (more so, indeed, than is shown in my figure); but in this species there is so much variability in their position that this cannot be regarded as a character of any importance. The present form must, I think, be ranked as one more modification of the *linearis* type. I have figured another specimen of this species (Plate IX. fig. 2), which illustrates still further the variability in the position of the avicularia.

Family **Escharidæ** (part), Smitt.

SMITTIA, Hincks.

Smittia nitida, Verrill.
(Pl. IX. figs. 5, 5 *a*.)

Zoœcia subquadrangular (very irregular in shape), disposed in linear series, separated by raised lines, slightly convex, areolated round the margin, or simply punctured, the surface very bright and lustrous, of a delicate white colour, covered with large polished granules; orifice suborbicular, somewhat flattened below; the peristome raised above and (especially) at the sides, where it rises into prominent points, not elevated in front; on the lower margin three denticles, two lateral and small, and one larger in the centre; on each side of the orifice (or on one side only) a subspatulate *avicularium* (narrow at top, and expanding towards the extremity) raised on a small mound; sometimes replaced by a gigantic curved avicularium, stretching down two thirds of the length of the cell. *Oœcium* rounded, thickly punctured in front, often invested round the base by a thick granular band; usually an avicularium with pointed mandible at the back; peristome continued as an arch across the front of the oœcium.

Loc. North America (*Verrill*); Africa, on coral (*Miss Jelly*).

Drawings of this species were prepared before I was aware that it had been figured by Prof. Verrill from North-American specimens. I have engraved them, as they show a remarkable modification of the avicularium not noticed by Verrill.

A detailed diagnosis has been added, no description accompanying his figure.

ASPIDOSTOMA, n. gen.

Gen. char.—*Zoœcia* with a calcareous front wall, destitute of raised margins; orifice arched above, straight below, protected in front by a broad shield-like plate, which is continued downwards for some distance within the cell; attached to the inner surface of the plate, on a level with the margin of the orifice, a semicircular membrano-calcareous (?) frame, into which the oral valve fits; wall of the cell elevated behind the orifice into a broad hood-like expansion, which covers it in and forms an arched secondary orifice. *Zoarium* (in the only known species) erect and bilaminate.

Aspidostoma crassum, n. sp.
(Pl. X. figs. 6, 6 *a*.)

Zoarium erect, compressed, thick, contracted towards the base, and widening upwards, of a reddish-brown colour. *Zoœcia* disposed in two layers, placed back to back, massive and thick-walled, quincuncial, very broad and rounded above, narrowing off downwards (pyriform), truncate at the bottom, divided by very deep sutures; surface dense, roughened; back of the cell elevated and forming a hood over the orifice, with an arched opening in front, the margin of the hood rising into two prominent pointed processes, between which there is a narrow cleft; orifice arched above, straight below, screened by a broad plate, with a thickened and everted edge, which conceals it and stretches across a great part of the arched opening; margin of the plate continuous with the wall of the hood, and forming with it on each side a loop-shaped opening; front of the cell somewhat flattened below the orifice and sloping down towards it; in the centre of this portion a raised elongate callosity; leaning against the side of many of the cells, a little below the upper extremity, an *avicularium*, with a very short, broad, subtriangular mandible directed upwards. *Oœcium* elongate, much depressed, shield-like, granulated.

Loc. Dredged between Patagonia and the Falkland Islands (*Capt. Cawne Warren*).

This very curious form is remarkable for the thickness and solidity of the zoarium and the massive character of the zoœcia. Young cells are less strongly calcified, and the hood is of much more slender make than in the adult, and does not project so far in advance of the orifice. It is always at this stage destitute of the marginal processes which give so peculiar a character to the adult zoarium*. In the old cells calcification is carried to a great extent, the upper extremity becomes very tumid, and the wall rises down the sides into a kind of mound, which partially closes in the depressed area below the mouth. The curious structure of the orifice will

* The figures do not show the very prominent and striking character of the hood, and its two marginal processes.

be best understood by referring to the figure. The lamina or plate which protects it is hollowed out in front. This plate passes down for a considerable distance into the interior of the cell; immediately within it is placed the semicircular frame on which the oral valve works, which fits close on to the inner surface of the lamina. The flattened, shield-like ovicell is another striking feature.

The structure of the zoœcium in this species is so remarkable that I cannot hesitate to refer it to a new genus. Busk, in his 'Catalogue,' describes an *Eschara* (*E. gigantea*), from South Patagonia, which bears some slight general resemblance to the present species; but neither the diagnosis nor the figure represents the essential peculiarities of *A. crassum*.

EXPLANATION OF THE PLATES.

Plate VIII.

Fig. 1. *Membranipora cervicornis*, MacGillivray, to show the structure of the zoœcium. The forked spines omitted, except in the case of a single cell, and only the fixed tubular base represented.

Fig. 2. *Membranipora* (*Caleschara*) *denticulata*, MacGillivray. In this figure the membranous wall, which closes in the entire front of the cell, is omitted, so as to display the calcareous lamina and the offset from its upper margin, which together form an inner covering over a considerable portion of the area. The semicircular oral valve at the top of the area must be understood to belong to the absent membranous front wall.

Fig. 3. *Membranipora setigera*, n. sp.

Fig. 4. *Membranipora bellula* (normal form), n. sp. 4 *a*. Ditto, var. *bicornis*. 4 *b*. Ditto, var. *multicornis*.

Fig. 5. *Membranipora terrifica*, n. sp.

Fig. 6. *Membranipora rubida*, n. sp.

Fig. 7. *Diachoris bilaminata*, n. sp. 7 *a*. Zoœcium with avicularium.

Plate IX.

Fig. 1. *Membranipora bicolor*, n. sp.

Fig. 2. *Schizoporella linearis*, Hassall. Variety with avicularia at the top of the cell and on each side of the oœcium.

Fig. 3. *Schizoporella linearis*, var. *quincuncialis*.

Fig. 4. *Membranipora patula*, n. sp.

Fig. 5. *Smittia nitida*, Verrill. [This figure represents a very irregular group of cells.] 5 *a*. Zoœcium with ovicell.

Fig. 6. *Schizoporella argentea*, n. sp. 6 *a*. Single zoœcium.

Plate X.

Fig. 1. *Membranipora coronata*, n. sp.

Fig. 2. *Membranipora permunita*, n. sp.

Fig. 3. *Membranipora cervicornis*, MacGillivray, var. 3 *a*. Oœcium.

Fig. 4. *Vincularia abyssicola*, Smitt. From an incrusting colony.

Fig. 5. *Epicaulidium pulchrum*, n. sp. 5 *a*. A single triplet of cells.

Fig. 6. *Aspidostoma crassum*, n. sp. Showing a group of cells from the younger and older portions of the colony. 6 *a*. Fragment of the zoarium, nat. size.

XVI.—*Note on a Central-Asiatic Field-Mouse* (Mus arianus). By W. T. Blanford, F.R.S. &c.

I am indebted to Mr. Oldfield Thomas for calling my attention to the fact that a Japanese species of *Mus* was named *M. erythronotus* by Temminck in 1850.

In the 'Annals' for 1875 I proposed the same name, *M. erythronotus*, for a mouse of which I obtained specimens at Kohrud, between Isfahan and Teheran, in Persia. A species apparently identical with the Persian mouse was collected by the late Dr. Stoliczka in Wakhán, a province on the Upper Oxus belonging to Afghanistan, and at Káshgar, in Eastern Turkestan; and the same form has since been found by Major Biddulph and Dr. Scully at Gilgit in the Upper Indus valley.

It is by no means certain that this form may not pass into the eastern races of *Mus sylvaticus*; and it requires comparison with *Mus sylvaticus*, var. *major*, of Radde; but as it appears to be a well-marked type, with a wide distribution in Central Asia, and as the name *Mus erythronotus* cannot be retained for it, in consequence of the prior use of the same specific denomination by Temminck, I propose to change the name to *Mus arianus*—from Ariana, one of the ancient names for Persia and the neighbouring countries to the eastward.

The following synonymy furnishes, I believe, all the necessary references:—

Mus arianus.

Mus erythronotus, W. Blanford, Ann. & Mag. Nat. Hist. ser. 4, vol. xvi. p. 311 (1875); Northern Persia, ii. p. 54, pl. v. fig. 3 (1876); Scientific Results Second Yarkand Mission, Mamm. p. 54 (1879); J. A. S. B. 1879, vol. xlviii. pt. 2, p. 97 (nec *Mus erythronotus*, Temm. Fauna Japonica, Mamm. p. 50, 1850).

Mus sylvaticus, var., W. Blanford, J. A. S. B. 1875, xliv. pt. 2, p. 108 (nec Linn.).

XVII.—*On the Origin and Formation of the Flints of the Upper or White Chalk; with Observations upon Prof. Sollas's Paper in 'The Annals and Magazine of Natural History' for December* 1880. By Surgeon-Major Wallich, M.D.

[Plate XI.]

As Mr. Sollas has seen fit to make the second part of his memoir "On the Flint Nodules of the Trimmingham Chalk" a medium for indulging in a number of unwarranted comments (for they cannot be called criticisms) upon my paper "On the Physical History of the Cretaceous Flints" (published in the 'Quarterly Journal of the Geological Society,' vol. xxxvi. No. 141, Feb. 1880)*, I shall first reply to his strictures, and then avail myself of the opportunity to furnish some additional facts and arguments in support of my views, which want of space debarred me from bringing forward in the paper just referred to.

That Mr. Sollas or any other professed geologist should have hesitated to accept my explanation as to the mode of formation of the Flints, and should freely canvass my facts as well as my conclusions, was not only perfectly legitimate, but no more than I expected when giving utterance to an hypothesis both novel and opposed, in some most important particulars, to all preconceived ideas concerning a difficult and avowedly unsolved geological problem. But I likewise expected, from a writer whose previous researches on kindred subjects (so far as I was acquainted with them) had yielded me both pleasure and instruction, at least a precise and impartial recital of such of my statements and conclusions as he felt called upon to impugn—together with some better results than a laboured and, as I venture to think, futile attempt to improve upon the well-known doctrine that "the flints are due to the replacement of carbonate of lime by silica" †.

Speaking generally, Mr. Sollas's paper contributes very little that can be considered original to our knowledge on the flint question—unless it be the interesting fact that the silica of the Trimmingham flints *may*, in part, have been derived from spicules belonging to, but now missing from, certain fossilized sponge-remains in the Trimmingham Chalk. For, although he devotes a considerable space in his paper to the chemistry of the subject, it is obvious that he has derived his inspiration, on almost every material point relating to the production of *flint*, from the splendid researches of Graham, to which, in common with myself, he appears to be indebted for whatever information he possesses regarding the colloidal properties and combinations of silicic acid and colloidal substances in general‡. Yet he offers no explanation of the cha-

* This paper was read before the Geological Society in December 1879.

† See paper by Prof. Rupert Jones, F.R.S. &c., "On Quartz, Flint, and other forms of Silica" (Proc. Geol. Assoc. vol. iv. no. 7, Apr. 1876, p. 447).

‡ Mr. Sollas mentions Mr. Graham's name only in relation to "the fact," *if it be one,* "that silicic acid has the property of actually combining with such substances as albumen and gelatin to form with them silicate of albumen and silicate of gelatin" (*loc. cit.* p. 452).

racteristic *forms* assumed by the flint nodules that may not be found in every geological textbook; and upon the most difficult and puzzling question of all (namely, the cause of the *stratification* of the flints), although he shows that he regards it as part and parcel of the Flint question, by just once (at p. 441) confessing it presents "*a* difficulty," from first to last he remains significantly silent.

I may observe, in reference to the last-mentioned fact, that I should have been content to discuss Mr. Sollas's theory of the formation of flint so far as it goes, and to leave entirely out of sight those points on which it would appear that he has been unable to arrive at any conclusion whatever, had he not indulged in such unjustifiable observations as the following:—"The last question which remains for discussion is the origin of the various external forms assumed by flint. A good deal of misconception appears to have arisen on the subject through a too exclusive attention to one particular form of flint arbitrarily selected as *a type of all others*. For this (generally the irregular nodular form) a theory is framed which is then made to account for the rest. Thus, when Dr. Bowerbank attempted to show that flints are silicified horny sponges, he accounted for the flint-veins of the chalk by supposing them to be horny sponges which had grown over the sides of an open fissure at the cretaceous sea-bottom; and Dr. Wallich, after giving an explanation of flint nodules and layers, speaks of the veins as formed by a 'sluggish overflow' of silica-saturated protoplasm 'into fissures in the chalk.' There does not appear much to choose between these rival explanations of the veins; both are attempts to *square* a preconceived hypothesis *with an obnoxious fact*" (*loc. cit.* p. 450).

Mr. Sollas is doubtless aware that Dr. Bowerbank can no longer answer for himself. He has, however, associated my name with that of a universally respected and known scientific thinker and writer, whose researches on the Sponges alone ought to have protected him from an imputation which, applied as it has been to myself as well as to Dr. Bowerbank, I can only describe as being wholly unfounded.

Mr. Sollas has taken care not to state at what page the words he here quotes from my paper are to be found. I will supply the omission. The seven words in question constitute the sole allusion to the flint-veins made by me, from beginning to end of my paper. The context, now furnished, will show that the *formation* of the veins was *not* what I was speaking about, but the "*homogeneousness*" *of the colloid material* contained in the fissures. In my paper I offered no other opinion whatever on the veins, for reasons which I considered sufficient—the allusions to sluggish overflows into the fissures of the chalk being made solely with a view to point out that, had they been filled with an *aqueous solution*, the fissures would not only have been lined with silica, but the walls of the fissure would, to a considerable depth, have become silicified through the absorbent power of the chalk. This view I still regard as valid, and as applicable to the tabular layers of chalk also. The following is the sentence from which Mr. Sollas has detached and quoted (as I shall show he has done in other instances) an incomplete passage, in order that he might impugn it:—"But that the colloidal *idiosyncrasy* of silica performed a much more important function in the phenomena connected with the flints than has heretofore been supposed, appears to me to be indicated by the evidence of the almost perfect incorporation of the organic silica with a colloid material, the unique amœbiform nodulation of the flints, and *its homogeneousness*, whether occurring in nodules, in *continuous sheets* parallel to the stratification, *or as sluggish overflows into fissures in the chalk*" (*loc. cit.* p. 89).

Again, at p. 451 of his paper Mr. Sollas says:—"In attempting to find an explanation for the form of these flints we may consider the following suppositions:—(i) The *form* may have been determined by the presence of animal matter (protoplasm, *Wallich*), or (ii) of the products of its decomposition," &c. . . . " The first explanation *may best be stated in Dr. Wallich's own words.* Thus, speaking of the irregular nodules, he says:—' those characteristic *amœbiform* outlines which, according to my hypothesis, are dependent on the presence of, and the combination of the silica with, the accumulation of nearly pure protoplasm still sufficiently recent to have resisted admixture with calcareous or other matter' (*loc. cit.* p. 79). As I have already shown in the earlier part of this paper that flints originate as silicified chalk, *we need not spend time on a formal confutation of Dr. Wallich's hypothesis*; but when Dr. Wallich remarks that ' the various conditions that present themselves from the earliest elimination of the silica from the sea-water to the period when it becomes finally consolidated, have never, that I am aware, been consecutively followed out' (*loc. cit.* p. 89), I would take the liberty to refer him to a paper of my own, printed in abstract in the Quart. Journ. Geol. Soc. vol. xxix. p. 76 (1873), *where the steps are perhaps as consecutively followed out* as in Dr. Wallich's paper itself. *As my paper has never been published in full*, I shall make no apology for giving here a rather lengthy extract from it" (Mr. Sollas's paper, 'Annals,' Dec. 1880, p. 452).

Both the above extracts from my paper are so incorrectly given, and mutilated by the omission of the context, as to materially alter their purport, at the very time that Mr. Sollas informs his readers that "THE FIRST EXPLANATION *may best be given in Dr. Wallich's own words*," and prefaces his first quotation by saying that I was "*speaking of the irregulur nodules*," in order to make it appear that I was then describing some part of my *hypothesis*. I was neither describing any part of my hypothesis, offering an explanation of any supposition, nor directly or indirectly making any allusion to the question of the nodules. I had been impugning a statement by Sir Charles Lyell, made under a misapprehension of certain facts which I was relating concerning the very insignificant part played by the Diatomaceæ in supplying the silica of the flints, and was repeating generally what I had been at great pains in proving, for the first time, by detailed evidence, that "the comparatively bulky siliceous framework and spicule-system of the deep-sea vitreous sponges must constitute the main source of supply of the material for the flints." Speaking of *this*, I continued as follows:—"Indeed, it is far from improbable that the true flints are produced solely in the areas occupied by the sponge-beds, the flints becoming (elsewhere) more cherty and DEVOID *of those characteristic amœbiform outlines* which, according to my hypothesis, are dependent" &c. (see my paper, p. 79). Therefore, to cite this passage as an "*explanation*" of my hypothesis, more particularly as it was not described by Mr. Sollas either before or afterwards, was a mere abuse of words, if not of facts!

In the second of the above extracts Mr. Sollas pursues the same course of destroying the purport of the passage by suppressing the context. Such a method of supplying the *ipsissima verba* of a writer might, in skilful hands, be so applied as to warrant the impression that the best hypothesis that ever was constructed was not worth the ink it was written with. In the present case, so finely had Mr. Sollas drawn the line as to deprive the sentence he quotes of a definitely expressed limitation, by omitting the word "But," with which it commences.

The following is the paragraph from which the extract is taken:—"That the predisposition of silica, itself in reality a colloid, to form colloidal combinations with albuminous and other materials was known long before deep-sea exploration was dreamt of, is a well-known historical fact; it has been alluded to by most of the writers who have attempted an explanation of the mode of formation of the flints. *But* the various conditions that present themselves, from the earliest elimination of the silica from the sea-water to the period when it becomes finally consolidated, have never, that I am aware, been consecutively followed out" (see my paper, p. 89).

It will be seen from this that I had distinctly shown, in the previous part of the paragraph from which the quotation is made, that I laid no claim to originality in reference to the abstract chemical questions concerned on the subject of colloids and notably of silica. Yet, incredible as it may appear, the four next pages of Mr. Sollas's paper, which are taken up with the said "lengthy extract," contain not a single observation that is not wholly connected with the chemical and molecular changes that take place in the formation of flint nodules, and the infiltration with silica of certain shells from the Blackdown Greensand beds, which has no direct bearing whatever on the questions now before us. Indeed the concluding paragraph of the extract proves this; for in it the writer says:—"Thus the crystalline state of flint nodules offers us no evidence for or against our theory of the formation of these fossils. This theory may be summed up under two heads:—(1) combination of silicic acid with animal matter of various kinds—*a chemical fact*; and (2) *concentration of the silica from the silicate of animal matter thus formed, by the extrication of the organic part of the compound. This is a pure assumption*, but one which agrees very well with other well-known facts in chemistry" (*loc. cit.* p. 456).

Again, speaking of the irregular forms of the flint nodules, Mr. Sollas observes, at p. 459 of his paper:—"These, by their fantastic flowing outlines, are responsible for much of the theorizing which can only regard flint as a silicification of organic matter. Thus, Dr. Wallich repeatedly lays stress on 'the unique amœbiform nodulation of the flints,' though one may remark that one of the characteristic features of an amœbiform outline is that it seldom remains the same two minutes together; and this cannot be said of flints, although, as Dr. Wallich speaks in another place of the flints showing 'signs of the specific contractility of colloid silica,' one might infer that he does not regard this character as absent. A flint moving by means of its pseudopodia would be an interesting object; but perhaps the distinguished writer merely alludes to the excessive shrinkage which colloid silica undergoes in passing from the pectous to the solid state; and certainly, to one who has experimented with colloid silica, the wonder on Dr. Wallich's hypothesis would be, not that the flints show signs of shrinkage, but that they do not present them more markedly. The time for conclusions based on superficial resemblances is now gone by; we no longer regard 'dendrites' as fossils on account of their moss-like form, nor profess to be 'able to tell an honest man by the smell'" (Mr. Sollas's paper, p. 459).

This extraordinary composition may, or may not, have been written in a wholly serious spirit. It has appeared, however, in a journal occupying a foremost rank in the scientific literature of our time, and is therefore calculated to engender an idea that it embodies a legitimate criticism upon views correctly ascribed to me. This is, in itself, a more than sufficient reason why it should be seriously answered, and why some other personal observations made by Mr. Sollas in the same journal, in regard to my writings, should receive distinct refutation at my hands.

Since Mr. Sollas has become so zealous an advocate for preciseness of expression on the part of a non-professional naturalist as to take exception at the use of the word *amœbiform*—which he alleges, but incorrectly, was "repeatedly" employed in my paper,—how comes it, I would ask, that, in the very same paragraph that contains his criticism, he should himself have described, in language of his own selection, and, it is to be assumed, conforming in all respects with his enlightened views, "the irregular and fantastic FLOWING outlines of the flint-nodules" as being "responsible for much of the theorizing" he refers to; my name being pointedly associated with this observation? And how comes it that, in the 'Annals' for December last (p. 38), he should, when speaking of the FORM of these nodules, have thus expressed himself:—"In form they vary greatly, some being flabellate, some irregularly conical, others consist of a somewhat ellipsoidal body on a short stalk, while many are irregular and AMORPHOUS"?

The word amœbiform, though a hybrid and but little removed from the Latin and Greek jargon which day by day threatens to drive plain English out of our scientific terminology, is undoubtedly expressive of the unique kind of *outline* and *nodulation* I desired to picture. There is no English equivalent for *Amœba*, and consequently none for *amœbiform*. Hence no other word could have adequately conveyed my meaning. It was accordingly used by me; and I stand by it.

Before passing on from this portion of my subject, I beg leave to say that the tone of Mr. Sollas's remarks, and more particularly of the last-quoted paragraph of his paper, would have been answered only by one general expression of reprobation on my part, but for the way in which he has attempted to make the personalities and other matters I complain of serve the purpose of depreciating my opinions, and has thus left me no alternative but to enter fully into the facts.

Mr. Sollas opened his paper by citing the opinion of Ehrenberg and Sir Charles Lyell (which he says "is supported by Dr. Wallich" and others) that the silica of the flints "has been derived from siliceous organisms, either collected into distinct layers or scattered through some other deposit, like the siliceous remains now found dispersed in the Atlantic ooze." A glance at p. 265 of Sir Charles Lyell's latest work, 'The Student's Elements of Geology,' will nevertheless show that such was not the opinion entertained in 1871 by that illustrious geologist. I can answer for myself, moreover, that no opinion of the kind has ever been entertained or expressed by myself, either elsewhere or in my paper on the Chalk flints. Referring to the analogy that has been drawn between the Atlantic mud and the chalk, and the inference which he alleges has been based on this analogy, "that siliceous organisms were at one time present in the chalk, just as they now are in the ooze," Mr. Sollas states that he will at once "proceed to make this inference independent of analogy, by showing that it is really nothing less than a statement of fact" (*loc. cit.* p. 438). And this he immediately claims to have done on evidence afforded by the Trimmingham flints, which goes "*straight to the point*," but which I venture to affirm leaves the inference as thoroughly dependent on analogy as ever it was—the only change in the situation being that, whereas I and other writers on the subject avowedly drew our analogy from analyses of chalk taken from the middle of a chalk-stratum, he drew his, not, as he pledged himself to do, from the Trimmingham *Flints*, but from chalk adherent to the crevices of the flint-nodules, and separated from them by washing and subsequent treatment with hydrochloric acid. It is true he does not confine himself in this matter only to the evidence afforded by the Trimmingham flints, but says his conclusions are supported by what he has observed at the Niagara chert-beds, the Carboniferous beds of Scotland and North Wales, and also in other English strata. But at p. 441 he says, in reference to "a difficulty" he has encountered:—"This is to be found in the restriction of the flints to definite layers in the chalk, the chalk above and below being free both from them and from sponge-spicules. It is difficult to see, in the first place, how a shallow sea came to consist of a strong solution of silica, and still more so to understand how it came to vary in a rhythmical fashion, sometimes being concentrated enough to lead to the formation of flints, and again pure enough to leave the intervening chalk almost absolutely devoid of silica." His "statement of fact," as derived from the occurrence of great numbers of sponge-spicules adherent to the nodules, goes for nothing therefore, in so far as the present question is concerned.

But Mr. Sollas claims to have obtained proof of another kind, in the presence in limestone-rocks of minute quartz-crystals and chalcedonized shells, and occasionally "numerous grains of silica with a radiate crystalline structure"—and notably in the mountain-limestone of Caldon Low, in which were found a large number of crystals, which he rapturously describes as being "six-sided prisms terminated by six-sided pyramids, the usual form of rock-crystal," and immortalizes by adding that it may "be accepted as a fact that in the mountain-limestone these beautiful crystals abound." A great many more details are furnished, relating to the microscopic measurements of these crystals, their being "beautiful polariscopic objects," &c., all of which information is no doubt excellent in its way, as showing that indubitable, minute, and perfectly-formed rock-crystals have "somehow" been produced from silica in aqueous solution; but in this, as in the previous case, not a single new or additional fact is brought forward which can in any wise connect the silica of the crystals with the silica of sponge-spicules, or furnish a pretext for assuming that they may not, with just as much probability, have been formed from the silica always held in solution in sea-water, and which is said to be derived principally from the comminuted siliceous débris of felspathic rocks brought down to the sea by rivers*. Therefore, until this connecting-link between the Trimmingham flints and the spicules found on the chalk adherent to them (but only mechanically) can be positively affirmed, and between "calcitized siliceous sponges and the deposited silica," which, we are told, "is generally to be found somewhere not far off," Mr. Sollas must not be surprised at my regarding these mere "inferences" of his—probable, no doubt, but still mere inferences—with even

* See 'Student's Elements of Geology,' by Sir Charles Lyell, 1871, p. 265.

less reverence than he regards the inference he could not deny was based, at all events, on a due amount of analogical reasoning.

But this raises the very important question, whether the Trimmingham chalk and flints can, for the purposes of the present inquiry, with any propriety be ranked in the same category as the typical chalk-strata, which have as certainly been deposited at abyssal depths in the ocean as the Trimmingham strata have been deposited in comparatively shallow water. On this point I do not propose to offer an independent opinion, but shall content myself with citing the opinions of experienced geologists, and amongst others of Mr. Sollas himself.

Referring, in the first section of his paper, published in the 'Annals' for November 1879 (which was *really* a treatise upon the Trimmingham flint-spicules and nodules), to the Sponges which furnished the still-existing spicules, he says these "lived on a sea-floor probably somewhere between 100 and 400 fathoms deep." In the later (*i. e.* December) portion of his paper bearing the same title, after noting the fact that "currents have had some influence" in causing an addition to the proper spicular complement "of the Trimmingham forms from Sponges of other kinds," he again admits "the flints" in this locality "were not formed at any abyssal depth," but at from "100 to 400 fathoms, giving a pressure of from 20 to 80 atmospheres," by which he considers the solution of the spicules in sea-water might have been aided*.

Now, according to the authorities on the subject about to be cited, it will be seen that the average depth at which the ancient Cretaceous mud was deposited is so vastly in excess even of the *maximum* depth indicated for the Trimmingham deposit, that the conditions under which animal life existed in the two regions do not admit of comparison. In the one region the water immediately overlying the sea-bed must have been in a state of practically perfect quiescence; in the other (as collateral evidence, to be presently produced, will show), the water immediately overlying the sea-bed must have been in a state of constant and perhaps even powerful movement, owing to tidal and other currents. In the one region, sponge-life (the now admitted chief source of the silica from which the chalk-flints were formed) was in all probability developed, as it is known to be in our own day, to an enormous extent; and with it, of course, the dense protoplasmic environment which forms an organic constituent of the deep-sea sponges,

* *Loc. cit.* pp. 442, 444.

and is, as I stated in my former paper, as indispensable a factor in the production of the flints, as they now present themselves in the Upper Chalk, as the silica itself which is derived from the sponge-spicules. In the other region sponge-life did, no doubt, occur to a certain and, possibly, considerable extent. But the condition of aqueous movement at the sea-bed during the deposition of the Trimmingham beds must there have constituted an insuperable obstacle (as it undoubtedly is to this day, at depths no greater than those determined for the Trimmingham beds) to the development of both the sponges and their protoplasmic nidus in sufficient abundance to lead to the formation of the typical black flint, which, according to my hypothesis, is as distinct in its mode of formation from the cherty varieties as the chert is distinct in its mode of formation from the chalk. Accordingly, the element of depth becomes a material factor in our present investigation.

Professor Prestwich, when referring to "Submarine Temperatures" *, in his Address delivered in 1871 at the Anniversary Meeting of the Geological Society, observed :—"From these considerations the question arises whether the deep sea in which the Chalk was deposited may not also have been a sea shut out from direct communication with the Arctic seas" (*loc. cit.* p. 39). . . . "I think, therefore, that the hypothesis with regard to the continuity of that sea-bed (the Post-cretaceous Atlantic) from the period of the chalk to the present is one of high probability" (*ibid.* p. 41). And again :—"The Chalk, attaining as it does a thickness of 1000 to 1500 feet, was always looked upon by geologists as *the deposit of a very deep sea*" (*ibid.* p. 46). Mr. Whitaker, in his excellent 'Guide to the Geology of London' (The Geological Survey of England and Wales : 1875), says :—"By its fossils the Chalk is proved to be the deposit of a deep sea—a deposit of much the same character as that now forming in the mid-Atlantic, and which, like the Chalk, is largely made up of the remains of microscopic Foraminifera" (*op. cit.* p. 19). And, lastly (though many additional authorities to the same effect might be cited), Professor Martin Duncan, during the discussion which followed the reading at the Geological Society of Mr. Sollas's own paper "On the Markings in the Chalk of the Yorkshire Wolds,"

* See the elaborate and admirable memoir entitled "Tables of the Temperatures of the Sea at different depths, reduced and collated from the various observations made between 1749 and 1868, with maps and sections. By Joseph Prestwich, M.A., F.R.S., &c.," Phil. Trans. Roy. Soc. vol. 165, pt. 2, 1874.

observed that "no reef-building corals are occupants of the deep sea, on which there is little doubt the Chalk was deposited" (Quart. Journ. Geol. Soc. 1875, p. 419)—an authoritative statement which it is somewhat unfortunate Mr. Sollas should have overlooked, inasmuch as it might possibly have saved him from drawing a very misleading parallel between the flints of the Trimmingham and those of really typical Upper-Chalk strata.

On the other hand, we have it on the authority of an observer, whose opportunities of arriving at a correct estimate of the mean depths at which the modern deep-sea calcareous deposits are being formed have never been equalled, that *there can be no doubt whatever* that we have, forming at the bottom of the present ocean, a vast sheet of rock, which very closely resembles chalk;" and "*there can be little doubt that the old chalk was produced in the same manner and under closely similar circumstances*" ('The Depths of the Sea,' 1872, p. 470).

But another, and perhaps the most material, fact in relation to the Trimmingham beds remains to be noticed. It is one on which I lay very great emphasis, as proving that a large proportion of the spicules (on which Mr. Sollas has based the whole of his superstructure of argument in relation to his hypothesis of the flint-formation as a whole) have, in all probability, been both drifted to and fro on the sea-bed and subject to very powerful disturbing agencies, and accessions from other more or less littoral localities, since the period when the associated Cretaceous deposit was formed. The fact referred to is described in a letter from Mr. Clement Reid, of H.M. Geological Survey of England and Wales, which was published in the 'Geological Magazine,' Dec. 2, vol. vii. p. 238. Mr. Reid, after remarking on another explanation that had been suggested, says:—"My difficulties in accepting the view that the contortions were formed by the dead weight of masses let down from above are, firstly, that I cannot find a single case where uncontorted beds have been deposited over the contorted one, though at first sight many sections have that appearance; and, secondly, that no weight we can imagine possible could drive up the solid chalk at Trimmingham in a ridge three quarters of a mile long from N.W. to S.E., and apparently about 250 yards wide, *this disturbance, it must be remembered, affecting not only the chalk, but 200 feet of overlying clays and sands.*" Any commentary on such evidence is, I submit, unnecessary; for, to quote a favourite expression of Mr. Sollas's, "these facts speak for themselves."

But, strange to relate, Mr. Sollas arrives at the conclusion that "the once existing spicules are absent from the Trimmingham deposit—not because they have been washed away, but *dissolved*; for they are invariably absent in fossil sponges and stratified deposits. Neither Zittel nor I" (he says) "have seen a trace of them; and my observations on the comparative readiness with which they undergo solution in—CAUSTIC POTASH, *serve to explain their absence*"! (*loc. cit.* p. 442).

If *these* are not "inferences," they are something more, namely pure assumptions—the first an improbable assumption, the second worse than improbable, since every schoolboy knows nowadays what the action of "caustic potash" is on silica, and that caustic potash is certainly not one of the ingredients which chemical analysts have heretofore detected in *oceanic* waters. It is therefore "a self-evident truth" that the solution of the Trimmingham sponge-spicules on the sea-bed could not, under any known conditions, have been due to the substance referred to, even were it possible for the alkali to exist in sea-water in the form of hydrate. Besides there is no other substance in sea-water which possesses even an approximate solvent energy upon silica. "The chemical fact" referred to (*loc. cit.* p. 456) cannot, therefore, under the most strained interpretation, be regarded as "serving to explain," or being connected with, "the absence of the spicules" from the Trimmingham deposit. Nor, coupling it with what has been previously advanced, can it be regarded otherwise than as demolishing Mr. Sollas's claim to having made a demonstrated fact occupy the place either of analogy or inference. And, going yet a step further, if we take the whole of the facts that have up to this point been recorded, I venture to think it has been indisputably proved that no parallel can be drawn, for the purposes of the present inquiry, between the Trimmingham Chalk with its flints and the White or Upper Chalk with its flints, or even the typical calcareous deposits of the modern Atlantic sea-bed. Should this conclusion be correct, it follows, as a natural consequence, that the whole of the arguments and hypotheses Mr. Sollas has, with so much confidence, based solely on evidence supplied by a shallow-water cretaceous deposit like that of Trimmingham, subject as it must have been to disturbing tidal and current-influences during the period of its deposition, and to still more violent and cataclysmal agencies afterwards, must be looked upon as untenable.

I will now proceed to consider two other important questions which have a direct bearing on the flint-formation. The first is:—Does the ordinary theory of replacement of carbonate of lime by silica, which has been so ably discussed by

Prof. Rupert Jones and others, account for all the phenomena? The second:—Is flint, the true black or typical flint of the Upper or White Chalk, a crystalline, or an amorphous and, to a certain extent, colloid body?

It has already been stated that, according to Mr. Sollas, "*flints originate as silicified chalk*" (*loc. cit.* p. 452). "It would appear (he says) that the simple deposition of silex is impossible in the Chalk; the first STAGE of deposition in this deposit is *always* that of replacement (*ibid.* p. 451)." And again:—"Briefly to sum up, a deposit of sponge-spicules accumulated in the chalk *ooze**, and in the presence of sea-water under pressure entered into solution. Replacement of the calcareous material of the ooze then ensued, small shells, and many large ones too, being converted into silex; and *siliceous chalk, not flint*, was the result. The chambers of the Foraminifera and the interstices of the chalk were *now* filled up by *a simple deposition of silica*, and the siliceous chalk became converted into *black flint*, an incompletely silicified layer of chalk remaining as the white layer of the surface" (*ibid.* p. 449).

It will, I think, be admitted that it is no easy matter to divine, from this extraordinary description, what the distinction is which the author desires to convey between *his* version of the replacement-theory, that "flint originates as silicified chalk," and the generally accepted view, that "the flints are due to the replacement of carbonate of lime by silica"—apart from the fact that the former is an unnecessarily complicated mode of expressing the latter, which, as it stands, is both plain and to the point. But it will be observed that Mr. Sollas divides the process into two distinct parts, which he dignifies by the name of "*stages*," without in any wise intimating what is to be gained by this division. The first stage (he tells us) commenced with the solution of the sponge-spicules in sea-water under pressure, and ended when the calcareous ooze, with some small shells and many large ones too, became converted into silex, through the replacement of carbonate of

* This is an assumption, since no accumulation of spicules "*in the ooze*" at all sufficient to account for the flint-formation has as yet been recorded by any deep-sea observer. I have seen nothing in the North Atlantic that could meet the requirements of the case. I was the first, however, to point out and furnish valid reasons for concluding that the substance called "*Bathybius*," which from the first I suspected to be no independent living organism, is merely the *effete* residuum of deep-sea organic life and the protoplasmic *nidus* of the deep-sea vitreous sponges, whose existence, in inconceivably vast numbers, over the calcareous areas of the sea-bed, had been conclusively demonstrated during the cruises of the 'Porcupine' and 'Challenger.' (See my paper "On the Cretaceous Flints," pp. 74–77.)

lime by silica—*siliceous chalk*, but *not flint*, being the result; whilst the second stage commenced with the filling-up of the *chambers* of the Foraminifera and the *interstices of the chalk* by a simple deposition of silex, and ended when the siliceous chalk became converted into black flint, an *incompletely silicified layer of chalk* remaining as the white layer of its surface.

The replacement-theory as taught by Prof. Rupert Jones* is undoubtedly applicable to the flints, so far as it goes. Mr. Sollas's version robs it of this attribute. For how and why the replacement by silica, admitted to have extended, during the first stage, to the *ooze* and some small and many large shells, should not, without let or hindrance, have, at the same time, entered the chambers of the Foraminifera, which, though small, present no peculiarity of structure that could interfere with the penetration into their chambers of the "simple" siliceous solution—how or why this solution should have reached the calcareous particles of the ooze and certain shells without gaining access to them through the *interstices* existing amongst the oozy particles themselves, and should not in the first instead of the second stage have silicified these interstices—and, above all, how or why the siliceous solution, which, from the commencement of the first to the final completion of the second stage, must necessarily have gained access to the interior of the mass of ooze by permeating its boundary-walls, should have failed throughout to silicify these, and should have left them in the shape of an "incompletely silicified layer of *chalk* remaining as the white layer of its surface," are problems far too subtle for ordinary understandings to grapple with, although Mr. Sollas appears to have long ago solved them to his own satisfaction, as the following remark, at p. 452 of his paper, somewhat personally attests:—

"As I have already shown, in an earlier part of this paper, that flints originate as silicified chalk, *we need not spend time on a formal confutation of Dr. Wallich's hypothesis*"!

These details may appear wearisome, and, could they be taken apart from Mr. Sollas's conclusions, might with advantage be ignored. They become important, however, when

* Prof. Rupert Jones qualifies the theory by adding:—"As this mineral (silica) rarely succeeds calcite as a true pseudomorph, it is only the amorphous, or detrital, carbonate of lime of the organisms constituting the limestone that has been replaced by silica (as flint &c.), and not the crystallized material of Echinodermatal spines &c. . . . . . the guards of *Belemnites*, nor the shells of *Inoceramus, Ostrea, Terebratula*, &c." (*loc. cit. antè*, p. 447).

viewed in connexion with the fact that they rendered it necessary for me to show on what grounds I reject those conclusions; and I mean from henceforth in this paper to discuss only the replacement theory of Prof. Rupert Jones, although compelled to dissent from it to the extent of maintaining *that it performs no part whatever* in the production of the true or black flint of the Upper Chalk, which, apart from its *imbedded pseudomorphs* of Foraminifera and other organisms, and their comminuted *débris*, I regard as having, from first to last, passed through the following stages:—first, in the state of inorganic, and probably some organic, silica held in solution in sea-water under the special conditions prevailing at the deep-sea bed; then, in the shape of sponge-skeletons and spicules*; next, of silica in its gelatinous and perfectly colloidal condition; and, finally, in the form of the flints.

In short, every imbedded pseudomorph, without exception, consists not of pure but of impure flint; in other words, it becomes cherty, and ought to be in the strictest sense regarded as an "*inclusion.*" Moreover the whole of these pseudomorphs included in, but not forming part and parcel of, the pure flint (of course omitting the large foreign bodies, such as Echinoderm and other shells, which so frequently form a nucleus, around or within which the colloidal silica has collected), if consolidated into compact masses, would rarely, if ever, occupy a space that would not be insignificant in comparison with the bulk of the remaining mass of pure flint in which they had been imprisoned. In their case replacement of carbonate of lime by silica must undoubtedly have taken place, precisely as it takes place when large masses of shell, as, for example of *Inoceramus*, have been accidentally entrapped in the still plastic and viscid colloid. But inasmuch as it would be a palpable error to regard such foreign bodies as integral portions of the flinty matrix, even though occurring in the highest stage of silicification, so long as there is the slightest trace of the opalescence resulting from the combination of the silicic acid with a mere remnant of the calcareous or fibrous tissues, so it would be a palpable error to regard the minute organisms which are almost invariably imprisoned in the flint, like insects in amber, as constituting integral portions of the imprisoning material. Or, *per contra*, if these are regarded as

* For the purposes of the present inquiry, I have deemed it inexpedient to include the Polycystina, and other minute siliceous-shelled structures, the silica of which, though undoubtedly contributing their quota to the general volume of the flints, exists in such a comparatively small proportion as not to deserve mention in discussing the general question of the flint-formation.

integral portions of the flint structure, so must the cherty rind or crust of the nodular flints, and the white outer coating of the tabular layers, both of which are due merely to the accidental entanglement in the still viscid colloidal mass of silica of minute calcareous organisms and their *debris*, "*the imperfectly silicified layer of chalk* remaining as the white layer of its surface," as it is very properly described by Sollas, be also thus regarded—a conclusion that would obviously be absurd.

Were the replacement theory applicable except in the case of the cherty varieties, there would be no such thing as pure flint; but we should have in lieu of it a composite mass, not homogeneous and, at times, almost translucent, but a substance identical in every respect with the cherty core that occasionally occupies what was, in the nascent state of the nodule, a portion of calcareous mud around which the colloidal mass of silica and protoplasm combined had closed in so as to form an internal chamber or cavity, the outer surface of the never *absolutely* silicified contents passing transitionally, though sometimes somewhat rapidly, from perfectly pronounced chert to perfectly pronounced flint.

It is true that Mr. Sollas seems to have such unlimited faith in the silicifying powers of his hypothesis that he sees no difficulty in supposing that "concentration of the silica" from the "silicate of animal matter," formed by the combination of silicic acid with animal matter of various kinds, may take place *by the extrication of the organic part of the compound*;" though he admits that this supposition is a "pure assumption which agrees very well with other well known facts in chemistry" (*loc. cit.* p. 456). At page 454 he says, "In all these and similar cases the silica, concentrated by the *dissipation* of the animal matter, which seemed in the first place to imprison it from solution, might remain in the crystalloid or the colloid state; at this distance of time we cannot determine." But even this extreme and ambiguously expressed view of the potentialities of colloid matter would hardly be tenable in these days, as explaining the only practicable way in which the annihilation—for it must be that or nothing—of the basal organic substance could be brought about which enters into the constitution of every shell and spicule, and which contains one elementary body that is certainly not an ingredient of pure flint, and could be got rid of *only* by entering into chemical union with another of the released elements to form carbonic acid. How comes it, then, that the constituent elements of the basal organic matter of the Foraminiferal and other calcareous, and, indeed, of all siliceous-shelled organisms, including the sponges themselves (whether we bury our heads and call it *spiculin* *, or *glairine* †, or acanthine ‡, or even *Bathybine* §), if all absolutely "*dissipated*," or "*extricated*," should leave *any* pseudomorphic forms behind at all? If pseudomorphs, the pseudomorph must represent *something* that has been replaced. But under the extraordinary conditions assumed by Mr. Sollas they can represent *nothing*—a logical situation from which I shall certainly not attempt to dislodge them, for most obvious reasons.

I may here mention another of the reasons which induce me to reject the replacement theory as applicable to the true flint. It is the fact that, were no powerful restraining influence at work on the sea-bed wherever the calcareous deposits occur, such as arises out of the nearly absolute insolubility in sea-water of sponge and Foraminiferal protoplasm, and of the now gelatinous and colloid silica in combination with it, instead of well-defined strata of chalk alternating with nodular and tabular layers of flint, the stratum of the one substance never encroaching upon or becoming deeply fused into the stratum of the other so as to render it doubtful where chalk entirely ends and silica begins (evidence being in this wise furnished of their insulation from each other being dependent on some chemical or molecular agency present in the one which is absent in the other), the replacement process would have had no definite limits, and must have been exerted indeterminately. This would have resulted in the production, in lieu of stratified chalk with intercalated and conformable layers of flint, of siliceous limestone, either with or without concretionary masses of chert distributed through it, probably without any regard to regularity. And, lastly, we should certainly not meet with nodular flints bearing unmistakable evidence of a highly colloidal origin. Nay, it is perhaps not going too far to say that, in such a case, the entire mass of organic rock known as chalk would, through the replacement of the whole of its carbonate of lime by silica, which had penetrated in a state of very dilute aqueous solution into every nook and

* Prof. Sollas's paper, p. 445.

† Alexis Julien, in ditto, p. 457.

‡ 'The Atlantic,' by Sir Wyville Thomson, vol. i. p. 340.

§ G. C. Wallich, *suprà*. I would repeat here what I stated in a footnote at p. 73 of my paper on the Flints, that I used the word "*protoplasm*" only because it is less specialized than either *sarcode* or *albumen*. It will be time enough to give it a distinctive name, as applied to enveloping albuminoid substance of the sponges or the basal organic substance of their siliceous parts, when we really know in what the distinction between the various guises under which protoplasm appears shall be more precisely determined than it has hitherto been.

cranny, have become converted into one stupendous pseudomorphic mass of compact silicified limestone.

It must not be imagined, however, that the views now so confidently advocated are based on mere assumption unsupported by a fair amount of relevant evidence—as relevant perhaps as any evidence can be that relates to natural operations that may in times past have been, or may even now be, carried on at abyssal depths in the ocean*. I have from time to time, during a long-continued study of the flint question, seen specimens of limestone thickly studded with fossil diatoms, not one of which, even when examined under a microscopic power amply sufficient to exhibit any loss of substance or form, exhibited the least trace of having undergone solution; the calcareous matrix of the limestone, crystalline and apparently deposited from solution, enclosed the diatom-valves, which remained as distinct from each other, although in the closest mechanical contact, as it was possible for them to be. It is, doubtless, both possible and probable that some of the more delicate of these structures may have undergone complete solution; for, as pointed out by me nearly twenty years ago, the *Acanthometræ*, a remarkable and very beautiful group of siliceous organisms inhabiting only the surface-waters of the open ocean, often in immense numbers, are never found in recent or fossil oceanic deposits. This I showed to be the result of the unusually large admixture of basal protoplasm with silica, of which their spines are composed, and which imparts to them a very distinct optical character, causing them, in virtue of this excess of colloidal matter, invariably to dissolve away in sea-water before their remains can sink down to the bottom. Some diatoms likewise present this character; and accordingly these may, if they formerly existed, have vanished from the limestone under notice. But, as already stated, the whole of those still visible remain perfectly intact, and, when seen in delicately cut sections, retain their characters so perfectly as to enable their marine origin to be positively determined.

As bearing directly on this question, I will here quote from my 'North-Atlantic Sea-bed,' published in 1862, with a view to show that even at that early date I had given the subject some careful consideration, though all my conclu-

* It is almost needless to point out that, in all questions relating to the conditions and changes taking place at the bottom of the ocean, assumption and hypothesis must, for many a day to come, occupy the place of demonstrated facts. Hypotheses are the advanced guard of knowledge, and, if properly equipped and cautiously sent forth, minimize the risks of fallacy when exploring an unknown region in science.

sions may not bave been strictly accurate:—"It is probable that the saline and mineral substances present in sea-water exercise a much more marked effect on the formation of the organic deposits of the deeper zones of the ocean than has been admitted under the 'antibiotic' view so often referred to. From the nature of the difficulties by which the inquiry is surrounded, not only is the chief portion of our knowledge regarding the deep-sea bed rather of a theoretical than a practical kind, but unfortunately it must long continue to be so. It is therefore doubly expedient to test this knowledge by the light of every fact that science or accident may throw in our way. . . . . If we examine the siliceous concretions, our perplexities increase rather than diminish; for whilst remains of siliceous-shelled organisms are to be met with in them, it is very remarkable that they do not belong to the family of siliceous-shelled Rhizopods that next to the Foraminifera are most largely represented at the bed of the ocean, namely the Polycystina; and *there is no authenticated example up to the* present period of a *Polycystine shell having been detected in a flint. From the nature of the hydrosilicates*, we could hardly expect to find the *forms* of siliceous organisms preserved; hence it is possible that the mineral atoms of the Polycystina have become merged as it were into the substance of the masses. But since we constantly detect siliceous spicules of sponges, which have not yielded to disintegration though similarly formed, it is difficult to reconcile the apparent anomaly. If we regard the concretions as principally made up of sponge-spicules, the case is but little altered; *for the pseudomorphs of the calcareous* shells of the Foraminifera are plentiful in their substance, and indicate that the conditions under which they were formed and silicified were such as might have been shared by the testaceous Rhizopods generally" (*op. cit.* pp. 120, 121). "Again, in those marine deposits in which the Diatomaceæ are sufficiently abundant and well marked to indicate that they had lived in the immediate locality, it may be taken for granted either that the water was shallow or that the deposit was formed along a coast-line, *since no Diatomaceæ* live at greater depths than from 400 to 500 fathoms. In the deep-sea beds where Diatomaceæ occur, the characters of the species, their variety, and their limited numbers, at once show they had been drifted from distant shallows, or were free floating surface forms which had subsided to the bottom after death. Whilst as yet we have no positive proof that the Polycystina live at extreme depths, it is a very significant circumstance that the large assemblages of these organisms hitherto met with in such a recent state as to indicate vitality occur in deep water, and that the forms taken alive at the immediate surface of the ocean in some latitudes are sufficiently distinct to prove that the same species do not occur at the surface and at the bottom without undergoing marked modification. On the other hand, there is reason to believe that some of the siliceous organisms met with in a living condition at the surface of the open ocean cannot live at any great depth, and that, *from some peculiarity in molecular constitution, the siliceous portion of their structure yields to the solvent power of the water. Thus the Acanthometrina*, a small group of organisms with siliceous frameworks of extreme symmetry and of such characteristic shape as to be readily distinguishable, occur in tolerable profusion in tropical and subtropical latitudes; *but, strange to say, not a trace of their siliceous remains is to be found either in recent or fossil oceanic deposits*" (*ibid.* pp. 126, 127).

I have still in my possession unmounted and mounted material obtained by me in 1857 from the surface of the Indian Ocean, and Southern and Mid-Atlantic Ocean, containing specimens, in considerable numbers, of *Acanthometræ*, *Polycystina*, *Dictyochidæ*, *Diatomaceæ*, and *Sphærozoidæ* — the mounted specimens in Canada balsam, the crude material in dilute alcohol. In both cases, the *Acanthometræ*, and some of the very delicate oceanic *Diatomaceæ*, with the thin-shelled *Sphærozoidæ*, were the first to show signs of solution, about ten years after they were obtained. In twenty years most of these had vanished as visible structures, but the *fluffy* residuum of their *sarcodic* bodies remained. Now some of the more solidly built forms are beginning to yield, and probably will do so in the course of a few scores of years, which, it is almost needless to say, is but a moment in comparison with the periods involved in any of the great chemical or molecular changes brought about in Nature. But, surely, no fact could be more clearly indicative of the potency residing in *protoplasm* than the one just furnished, these minute siliceous structures having, undoubtedly, given way under the powerful colloidal properties of what was once their own body-substance.

What, then, do these facts prove? First and foremost, they prove, by the presence of forms belonging to genera which invariably live along coast-lines*, and possessing stalk or cushion-like processes whereby they anchor themselves to rocks or shells, or algæ at the bottom of the sea, that the deposit in which their remains occur could not have been formed at any great distance from land, and that they were, in all pro-

* At depths probably never exceeding 50 or 60 fathoms.

bability, drifted by tidal or other currents into those areas in which they became finally accumulated. This, coupled with the almost entire absence of sponge-spicules, tends moreover to prove that there were no siliceous sponges in those areas, and, consequently, that the only substance which would have *ensured* their solution, namely sponge or Foraminiferal protoplasm (for in like manner no Foraminifera are observable in the limestone), *was entirely wanting.* Hence their immunity from destruction and perfect preservation in the limestone.

Of the existence of pure Diatomacean deposits at much greater depths in the ocean and at vastly greater distances from land than those just named, there is, as every biologist knows, abundant evidence—for example, in the antarctic regions, where they were discovered by Sir Joseph Hooker in 1843, and thirty years later by the naturalists on board the 'Challenger.' I have now before me sections of a Norwegian limestone literally crowded with marine diatoms of the kind already described, which are also in the same perfect state of preservation,—the inference I draw from these facts being that the unaltered condition of the organisms under notice is due to the very limited power of sea-water at moderate depths, and consequently under moderate pressure, even when aided by abundant products of animal and vegetable decomposition, to reduce silica *to a colloidal state;* and, conversely, that the superabundance, over the deep-sea calcareous areas, of siliceous sponges and their concomitant protoplasmic investment furnishes us with a highly probable and satisfactory explanation why flint-formation has taken place under one determinate set of conditions and has failed entirely to take place where these conditions are absent.

Reasons have already been given by me for regarding the simple deposition of silica from an aqueous solution, whether in the condition of flint which Mr. Sollas describes as "*crystalline,*" or of pure rock-crystal, as furnishing no parallel whatever to the process of the true chalk-flint formation as it occurs in the chalk strata, in which I contend there is no *deposition* of silica in the ordinary acceptation of the term, but a still more simple process of solidification of two gelatinous colloids "*more or less rich*" (to quote an expression of Mr. Graham's) "*in combined water as at first produced,*" but which gradually part with their "combined water" to the surrounding medium, under the dialyzing action of their own gelatinous substance, and become more and more consolidated until the period arrives when they have lost the whole of their "hydration," and then "appear as a *colloidal glassy hyalite*" (in other words, as typical flint): see an invlauable paper by Mr. Graham, "On the Colloidal Properties of Silicic Acid and other Colloidal Substances," Proc. Roy. Soc. for June 2, 1864, p. 335, where nearly the whole of the changes and processes I have described, although not with relation to deep-sea siliceous deposits, will be found most lucidly set forth.

Mr. Sollas alludes throughout his paper, with one exception to be hereafter mentioned, to the flints as being composed of "*crystalline silica.*" This expression strikes me as being so remarkable that I must quote some of the passages in which it occurs. Thus, at p. 445, "The silica of the sponge-skeletons occurs in conjunction (or probably in combination) with an organic basis known as *spiculin*; on solution it is liberated from the spiculin, and exists in a colloid state, whence it readily passes into the pectous condition, and subsequently becomes hyaline; it is, moreover, probable that, *under conditions not yet investigated*, a solution of colloid silica may give rise *directly* to silica in a crystalline form." Again, at p. 455, alluding to the silicified Blackdown shells, he says:—"The crystalline silica, which the percolating water carries in solution, passes through the shell, and in some cases, under favourable conditions, crystallizes out in long fine prisms." At p. 456:—"Thus the crystalline state of the *flint nodules* offers us no evidence for or against the theory of the formation of these [the Blackdown] fossils." And "*from this process of reasoning* we conclude that colloidal silica has the power of changing, in course of time, into a static or crystalline condition." And, lastly, reverting to p. 445, from which the first of these extracts was taken, we find the "crystalline" view thus emphasized:—"If it be objected that in this expanded explanation fact and conjecture are mixed together, I to some extent admit it, but at the same time remark that there is no conjecture in the statement that the silica which passes into solution is very different from the silica which has passed out of solution. The one may be conveniently called organic, and *the other mineral silica*; the properties of the two are strikingly different; and the process which has really happened has been a solution of organic silica and a deposition of mineral silica, not a solution and deposition of the same kind of silica." The last truisms are quoted only because, as the entire passage stands, the term "*mineral silica*" would seem from the context to be a convertible term for "*crystalline silica.*"

On the other hand, I subscribe to the opinion which, if I mistake not, is very generally entertained by chemists, that the *flints* are neither perfectly pure, nor, under any circumstances, a truly crystalline form of silica—silica being of course the principal but not the sole constituent of the black flint met with in the chalk, which is a compound substance consisting of a purely flinty matrix, within which varying numbers of the disintegrated remains of minute calcareous and siliceous organisms may almost invariably be detected on careful examination. Thus, in Phillips's 'Elementary Introduction to Mineralogy,' the following, according to Klaproth, are the constituents of flint—"98 per cent. of silica, with minute proportions of oxide of iron, lime, alumina, and water."

It may also be here stated with advantage that, according to Graham, silicic acid or silica becomes more and more insoluble the purer or more free from combined water it becomes. Hence the gelatinous compound formed by the ready and intimate combination of organic silica with, and also within, a mass of protoplasm, *which is already an insoluble colloid*, is to all intents and purposes no longer *either soluble or miscible with water*; whilst on the question of crystallization Mr. Graham says, "I may *add that no solution, weak or strong, of silicic acid in water has shown any disposition to deposit crystals*, but ALWAYS appears, on drying, as a colloidal glassy hyalite. *The formation of quartz crystals at a low temperature, of so frequent occurrence in nature*, remains a *mystery*" (Graham, *loc. cit.* p. 335).

It is of the utmost importance to bear these last-named characteristics of silica constantly in mind, as upon them depends the preeminent tendency of this substance to enter into colloidal combination with any albuminoid substance, such as animal protoplasm. On the other hand, it is equally important to bear in mind that silica, the moment it has assumed its gelatinous state, although holding in combination a certain portion of water, *is practically insoluble in water.* Hence its inherent tendency, when combined directly with protoplasm, not to imbibe more water, but to part with all but the infinitesimally minute trace that remains in combination with it up to the period when it is exposed to atmospheric agencies on dry land—this expulsion of its combined water being the result partly of dialytic action, as already mentioned, and partly of its idiosyncratic tendency to contract (Graham, *loc. cit.* p. 336) more and more upon itself, and thus favour the expulsion of all but the last residuary quantity, before final and complete consolidation into flint*. This consolidation is

* I have seen an interesting fact stated (but where, I am at this moment unable to remember), that flint-workers always find the flint softer and more easy to cut away in flakes immediately after it is extracted

also shown by Graham (*loc. cit.* p. 337) to be greatly assisted by the presence of alkaline salts and more particularly of *carbonate of lime.*

According to Mr. Sollas's statement already referred to, silicic acid forms, with albumen and gelatin, *chemical* compounds, *silicate of albumen*, and *silicate of gelatin* (*antè*, p. 163, note), and Mr. Sollas reasons upon it as if it were an indisputable fact. It may be so; but, until I have some substantial proofs of the fact, I confess I shall continue disinclined to believe that any chemical compound, such as silicic acid, or protoplasm, can be broken up into its elements by simple mechanical means, such as solution or diffusion. Thus glycerine and water may be mixed in any quantities without losing their chemical identity. So may two gelatinous and colloidal substances, as in the case of silicic acid and protoplasm, as soon after the death of the parent organism as the purely material forces step into the field to cause a combination of the silica, which had, *in the first instance only*, yielded so far, but no further, to the *quasi*-chemical action by which silicic acid, in the presence of a powerful colloid, exchanged one unstable condition in which it can exist without chemical disruption, for another unstable condition in which it can also do so.

On these grounds I contend that the union of these two substances is a purely mechanical combination or intermixture, whereby they become amalgamated, as it were, *into an organic alloy,* capable of retaining just sufficient "combined water" not to interfere, in the least degree, with their mutual insolubility in the surrounding water. Organic silica, or, in other words, *silicic hydrate*, in the presence of protoplasm only, passes into its gelatinous phase as soon as the preservative action of the *living* organism ceases with its death. "Decomposition" at the sea-bed, in the presence of the various saline preservative substances contained in sea-water, the low temperature prevailing, and the stupendous pressure (which, in all probability, prevents any gaseous body from existing, save in its fluid condition), must necessarily be an extremely slow process. In the combined state of colloidal silica and protoplasm their insolubility helps still further to protect them from decomposition by excluding substances which might otherwise enter into chemical combination with them. They constitute an independent *regnum in regno*, the permanence of which is interfered with only by the inherent and powerful tendency of

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from the chalk rock. This would appear to be in some way related to its retaining its permanent minute residuary quantity of water only until its exposure to the action of the atmosphere.

the combined mass of colloidal silicic acid and protoplasm to contract upon itself, and thus to bring about, by slow and sure degrees, the separation of its combined water. But it is not until the transition is actually imminent, from the plastic condition of the still nascent flint nodule to the final consolidated state when the nodule may be regarded as complete, that the minute residuum of water, enabled under the enormous pressure to retain a portion of pure silica in solution, yields, for the first time since it formed a component portion of the siliceous mass, to purely chemical forces, and thus, by dialytic action, escapes in its elementary form from its long imprisonment. It is during the entire period, dating from the death of the parent organisms that furnish the silica and protoplasm, up to that at which the final consolidation takes place, that the innate tendency to the assumption, by the continually contracting mass, of the peculiar external forms which so signally characterize the flint nodules, exercises a determining effect upon them—this effect being in all probability at its *maximum* of energy in the early stages of the masses, and at its *minimum* in their latest stages, but never absent or materially interrupted in the quiescent solitudes of the ocean. It shall be shown hereafter *that dead and effete albuminoid matter, as well as living, evinces this tendency to assume* what I have termed, in the absence of a preferable word, *amœbiform outlines.*

The varying number and contiguity of the flint nodules in different strata of chalk, and in different parts of the same chalk-beds, prove that these variations are due to varying extent, bulk, and rapidity of growth of the sponge-fields and their enveloping nidus of protoplasm, both the siliceous and the albuminoid portions of these organisms being contributories to the flint-formation. Did the nodular flints really originate, as alleged by Mr. Sollas, in silicified chalk—if by this expression we are to understand that a siliceous solution derived from the solvent action of sea-water on the spicules, aided by a partial admixture with the products of decayed organisms, "replaced the calcareous material of the ooze, . . . that siliceous chalk (not flint) was the result, . . . and, subsequently, this siliceous chalk became converted into black flint, an incompletely silicified layer of chalk remaining as the white layer of its surface"—it is very difficult, if not impossible, to conceive why or how such flint assumed, under any ulterior conditions short of re-solution and combination with a plentiful supply of colloid matter, the amœbiform outlines I have so often alluded to. The replacement of carbonate of lime—whether in sponge-cavities, shells, the tests of Foraminifera, or masses of calcareous ooze—has never, that I am aware, been found coupled with change of form. On the contrary, we have in almost every pseudomorph, whether consisting of carbonate of lime after silica, or silica after carbonate of lime, or an admixture of both carbonate of lime and silica, a well-defined retention of the general outline of the object, although extending only to the ghostly remnant of the organic basal matter to which reference is made.

The necessary evidence is, I submit, therefore complete, of the black flint* not being the product, in any sense, of the replacement of one mineral substance by another, but the *direct* resultant of the gradual transition of its silica from a gelatinous to the "pectous" condition, during which the last removable vestige of its "hydration" is expelled and the production of "*the hard stony mass of vitreous substance*" called flint is consummated.

As these remarks apply more or less to the entire flint-formation, including the cherty varieties, I hereto append a few short passages from Mr. Graham's paper on silicic acid, to which I have already been so deeply indebted for guidance in the present inquiry, as I should of course wish to give the whole weight of that illustrious physicist's scientific authority to the statements that have been put forward on the subject. Having done so, I shall consider my case concluded, so far as the mode of production of the flints is concerned.

"A dominating quality of colloids," Mr. Graham wrote, "is the tendency of their particles to adhere, aggregate, and contract. This idio-attraction is obvious in the gradual thickening of the liquid, and, when it advances, leads to pectization. In the jelly itself the specific contraction in question, or *synœresis*, still proceeds, causing separation of water, with the division into a coagulum and serum, and ending in the production of the hard stony mass of vitreous substance, which may be anhydrous, or nearly so, when the water is allowed to escape by evaporation. . . . Bearing in mind that the colloidal phasis of matter is the result of a peculiar attraction and aggregation of molecules, never entirely absent from matter, but greatly more developed in some substances than in others, it is not surprising that colloidal substances spread on all sides into the liquid and solid conditions. . . . It is unnecessary to return here to the ready pectization of liquid silicic acid by alkaline salts, including some of very sparing solubility (such as carbonate of lime), beyond stating that the presence of carbonate of lime

* Throughout my paper I have spoken of the *black flint* and the *typical flint of the upper or white chalk,* only because the characters I wish to account for are most strikingly seen in it.

in water was observed to be incompatible with the coexistence of soluble silicic acid, till the proportion of the latter was reduced to nearly 1 in 10,000" (*loc. cit. anteà*, pp. 336, 337).

Of course, between the most highly developed cherty form of flint and that in which is an admixture of foreign particles, of whatever kind these may be, there is an almost infinite gradation, depending, as I have in a former page pointed out, on the replacement, *now taking effect for the first time*, of carbonate of lime by silica. In order to understand by what very simple means this result is brought about, I will endeavour to illustrate it by the diagrams in the Plate accompanying this paper, representing four of the most common forms in which the typical nodular flints are met with in the Chalk, all peculiarities as regards external form being of course dispensed with as irrelevant to the present inquiry. For this reason each of the four nodules is supposed to have been more or less spherical (a condition, by the way, in which they are not unfrequently met with), and to have been split in half, so as to exhibit the flat and broken surface of one of the hemispheres.

In figure 1 we have a solid mass of typical black flint, surrounded exteriorly by a whitish crust or layer, the thickness of which is immaterial, inasmuch as it depends almost entirely on the degree of comminution and purity of the deposit in the spot at which it was formed. The portion which is now a mass of the typical black flint (marked B in all the figures) consisted originally of an accumulation of effete sponge-spicules and network, which, immediately after the death of the parent sponge to which they belonged, became loosely distributed within the substance of the also effete investing protoplasmic *nidus* *. Here they would be retained, more or less free

* "Effete" is not meant to denote a state of decomposition in the common acceptation of the word, inasmuch as every known fact tends to show that no such process takes place at profound depths in the ocean. Disintegration (*i. e.* tumbling to pieces) may, and no doubt does, take place, either in obedience to mechanical, chemical, or molecular forces, under the operation of which dead organic matter is enabled to enter into new combinations. This distinction is more important than it at first sight appears to be, since there is reason to believe that in such an elementary substance as sponge-protoplasm, and likewise in the examples known to every algologist, in which the development of a protoplasmic *nidus* or "*thallus*" is often so enormous in comparison with the dimensions and apparent capabilities of secretion of the organisms producing it, that it is extremely difficult to understand by what subtle or simple function (if it be indeed simple) such a massive adjunct can be produced and maintained for lengthened periods. The singularly rapid disruption of this adjunct, following upon the death of the organism of which it formed a part, furnishes one of the most instructive and significant commentaries we could desire upon the complete

from contact with sea-water, owing to the insolubility and coherence of the protoplasm, and would in due time yield to the powerful solvent influence of this substance (an influence which is at its maximum when exerted between substances that are colloidal), and eventually, by parting with their hydration in obedience to the law which governs these bodies, as their state of pectization became more perfect, would become consolidated into black flint.

Wherein, then, does the external whitish layer or crust of the nodule, and which also forms a crust or coating over the surface of the tabular layers of flint, differ in its mode of formation from that I have just been describing—namely, of the central mass of black flint? The explanation, I contend, is both simple and conclusive. At this stage of the formation of the nodular mass (not in point of time, but of material) replacement of the carbonate of lime by silica, *rarely, if ever, a complete process* *, comes into operation. An examination of sections of nodules embracing both a portion of the true flint and of its outer investing crust of *chert* will show that the transition from pure flint to well-pronounced chert is a gradual one, so gradual, indeed, that it would often be difficult, were not a difference of colour apparent, to recognize it, except by the impairment of the vitreous character, conchoidal fracture, and translucence which distinguish the flint from the crust of chert. Seen, however, as a section under the microscope, it is always visible. On the outer aspect of the cherty crust, on the other hand, there is no gradation observable either as regards colour or texture; for, although in nearly every nodular mass a certain quantity of unmetamorphosed chalk is closely adherent to it externally, a very little trouble will show that not a trace of siliceous percolation has extended beyond the peri-

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dependence of organic matter for its continuance, *as living matter*, upon the unknown quantity we call life. A mere breath destroys the link that binds together the animate and inanimate; and, as if eager to regain the sway they once enjoyed, when life "was not," the material forces of nature set about their normal task of disintegrating and reconstructing the elements which had for a time so successfully set them at defiance. If we extend this conception (and there is no reasonable ground for saying we have no warrant for so doing) to the stupendous development of sponge-life at the bed of the ocean, we shall not experience difficulty in comprehending how the silica and the protoplasm of the sponge, which respected each other's rights so long as the vital force presided over them, should, under the now unrestrained action of their powerful combining tendencies, interact upon each other in the way that has here been indicated.

* Mr. Sollas (at p. 449 of his paper) speaks of the white outer crust of the flints as "an incompletely silicified *layer of chalk*."

phery of the cherty wall, the adhesion of the cretaceous particles being due solely to their having become imbedded here and there, while the flinty mass was yet in an unconsolidated state, into little pits or cavities formed by the pressure of the cretaceous particles themselves, or into other equally accidental irregularities of the surface of the nascent nodule. The adherence of any portion of chalk to the nodule is a mere mechanical adherence arising out of the grip thus secured.

Now, according to the replacement theory, the entire mass of black flint was at one time a mass of calcareous ooze, which, becoming impregnated with a fluid aqueous solution of silica, became gradually silicified. Had this really taken place, one of two things must have happened: either the replacement of the calcareous material must have begun from some central point or points, by the admission of the siliceous solution into the centre of the mass through some channels which communicated with the surrounding medium—in which case a period must have arrived at which the external layer of the mass undergoing silicification must also have come under the influence of the replacing siliceous fluid and have in its turn become completely converted into black flint, the replacement thus extending radially from the centre of the mass to its periphery; or the replacement must have taken place from without and extended centrewards. It will be obvious, however, that under the latter supposition the outer coating must of necessity have been the first portion of the mass to be converted into flint. But it is almost needless to observe that in neither case is the theory of replacement borne out, inasmuch as in the first-named case the outer coating must sometimes, at least, have been converted into black flint—a condition in which it is never found; and in the second case, the silicification having begun from the periphery towards the centre, nodules must occasionally have been met with in which a coating of black flint (*not possessing a cherty external layer*) surrounded the yet unmetamorphosed central calcareous mass—another condition in which we never find it unless under the wholly exceptional circumstances where the nodule has, after separation from its chalky matrix, undergone attrition.

In the early nascent state of each nodule no chemical replacement of mineral for mineral has taken place on either side—the extensions of the colloidal siliceous jelly, and the intervening masses of calcareous deposit interlacing mechanically, and changing their relative boundaries only in obedience to the slow contraction going on in the colloidal mass towards its own centre or a centre or *point d'appui* consisting of some shell or other foreign substance that happened to come in the way and became thus accidentally enveloped either partially or wholly. According to Mr. Graham, "a dominating quality of colloids is the tendency of their particles to *adhere, aggregate, and contract.* In *the jelly itself the specific contraction or synœresis still proceeds, causing separation of water with a division into a clot and serum, and ending in the production of a hard stony mass of vitreous structure*" (Graham, "On Silicic Acid and other Colloids," Proc. Roy. Soc. vol. xiii. no. 65, June 1864, p. 336).

Here, then, is the key to my hypothesis, and, as I conceive, proof that the characteristic features, including the stratification and nodulation of the flints, are due to the inherent properties of the double colloid formed by the intense disposition of the colloidal protoplasm to enter into mechanical union (as in the case of glycerine and water) with the organic silica of the sponge-spicules and network—this tendency dating, however, *only* from the period when they ceased to be integral portions of a living structure and had already become only its residuary substances.

Having now explained, but still too cursorily to admit of my producing all the evidence that could be adduced in support of my view, the processes whereby the nodules and tabular layers of flint and the cherty varieties are formed, from the earliest to the latest stage of their nascent condition, it remains for me to connect these with my hypothesis in such a manner as to show:—firstly, the adequacy of the hypothesis to account not for one, or two, but for all the distinguishing features of the flint-formation as it now presents itself in the Chalk; and, secondly, in what respects the replacement and other theories that have been proposed must be considered faulty and insufficient to account for any thing more than the formation at the bed of the ocean of an impure flint, and the silicification of certain calcareous-shelled creatures which are entombed in the chalk and flint. I cannot secure this end more readily and, under existing circumstances, more appropriately than by quoting such portions of my former paper as bear on my hypothesis. But for the reasons assigned I should, of course, have been content to append references to the pages in question.

Referring to the insufficiency of the hypothesis previously offered in explanation of the Flint-formation, I asked:—

"Whence, then, did all the silica come? Why is it almost invariably found existing in layers parallel to the stratification of the Chalk? And what has really been its history, from first to last?

"It is to these questions that I hope, on the present occasion, to be able to furnish such answers as shall, at all events, form the groundwork of a good working hypothesis, and one capable of further elaboration as time and opportunity permit. Meanwhile I may be allowed to state that the conclusions arrived at by me have their origin in the assumption that, in the nearly total elimination of the organic silica from the organic carbonate of lime, in the almost constant aggregation of the colloid silica around some foreign body, in the ultimate consolidation of the colloid material into nodular masses or more or less continuous sheets, in the stratification of these masses and sheets, and, collaterally, in the perfectly preserved state of many of the Cretaceous fossils, are to be discerned the successive stages of a metamorphic action, whereby the protoplasmic matter and silica present on the sea-bed, after having first passed through an organic phase capable of resisting disintegration and decay, became once more amenable to those purely material forces in obedience to which they entered upon their new and secondary phase as Flints *.

"But even yet the chain of metamorphic action must have remained incomplete but for the manifest connexion which I was fortunately enabled, in 1860, to trace out between each of the successive stages referred to and a condition of things at the sea-bed then for the first time noticed—namely, that the entire mass of animal life there present is confined to the immediate surface-layer of the muddy deposit, alternating periods being thereby established, during which one of the two predominant animal types (Foraminifera and Sponges) gradually overwhelms and crushes out the other over indefinite local areas, the strata of chalk in the one case, and the intercalated flint-beds in the other, being the issue of these contests.

"Should it be asked, Why, then, do we find so striking a lithological difference between the Chalk and the Atlantic mud? the answer is, because our specimens of the mud represent only the constituent materials forthcoming at a depth of a few inches beneath the surface, where, if my hypothesis be correct, there must needs be accumulated nearly the whole of the silica. Whereas, were it possible to obtain specimens, say, from a depth of even a few feet, we should find that all, save the small residuary portion detected by analysis in the Chalk, had in like manner been eliminated from the mud."

* "Much valuable information 'on Quartz and other Forms of Silica' will be found in a paper bearing this title, from the pen of Prof. Rupert Jones, F.R.S. Unfortunately I was unable to avail myself of it, being unaware of its existence until the present communication had been laid before the Geological Society."

"A very important fact has to be here noticed in relation to the siliceous materials which are supposed to be normally and uniformly distributed throughout the substance of the calcareous mud at the period of its deposition on the sea-bed. In order to understand the full significance of this fact, it is indispensable to recollect that, whereas the carbonate of lime of the effete Globigerinæ and other foraminiferous shells is to a certain extent redissolved in the water charged with an excess of carbonic acid, and the amount thus abstracted is too insignificant to produce any material diminution in the mass of the calcareous deposit, nearly the whole of the organic, and probably a not inconsiderable proportion of the inorganic silica which has been found present in some specimens of the Atlantic mud, is dissolved under the conditions that prevail. For, whereas the calcareous matter is furnished partly from the débris of Foraminifera which pass their existence only at the bottom of the ocean, and partly from such as live at the surface and subside to the bottom only when dead, *the whole of the silex-secreting organisms, with the solitary exception of the sponges, subside to the bottom only after death.* The result is, that the *whole* of the organic silica, the moment it reaches the bottom, comes into contact with the protoplasmic layer and is retained by it. *Hence the quantity present in every sample of mud obtained (as all our samples hitherto have been) by a mere dip into the superficial stratum of a few inches in depth, does not fairly represent the percentage of silica contained and supposed to be equally distributed in the substrata, but only the accumulated amount of that substance which has been getting accessions for an indefinite period from the superincumbent waters.*

"In the case of the sponges that occur in such numbers on every square yard of the calcareous mud, and live more or less imbedded in the soft and luxuriantly developed nidus of their own protoplasm, the result described must necessarily take place in a still more signal degree, since every spicule, and every particle of their siliceous débris, is not only formed but accumulated within this protoplasmic environment. Therefore, instead of there being from 25 to 35 per cent. of silica, soluble and insoluble, in the calcareous mud, at a depth, say, of eighteen or twenty-four inches below the surface there is in all probability not more than is to be met with in an average specimen of white chalk.

"If we follow out to its legitimate issue a continuance of such conditions as have been here described, it is obvious that a period must arrive when the protoplasmic masses (which, owing to their inferior specific gravity, always occupy this position in relation to the calcareous mud, upon which they may be said to float so as to form an intermediate stratum between them and the superincumbent water) will become, if not supersaturated with silica, at all events so highly charged with it in a now colloid state more and more closely approaching coagulation, as eventually to asphyxiate, so to speak, the very organisms which have produced them.

"If we turn to the less prominent, because negative, conditions that prevail at the sea-bed, we shall perceive that they are of a kind specially favourable for securing uniformity of results, both as regards the time occupied in their completion and the nature of the changes which are effected by them. Thus we know that the abyssal waters closely bordering on the sea-bed itself are, in the majority of cases, in a state so nearly approaching perfect quiescence, that no current of sufficient energy exists to divert from their downward course particles of matter so light and feathery as to have taken probably many weeks, if not months, to sink down from the surface of the sea to their final resting-place at the bottom. On the other hand, there is nothing as yet known that could lead to the inference that the periods required for the deposition and consolidation of each succeeding stratum of chalk, and its accompanying stratum of flints, bear any proportion to those gradual and more rarely recurring secular changes in the direction of the great oceanic currents which (to repeat Sir Charles Lyell's words) favour at one time in the same area a supply of calcareous, and at another of siliceous matter; whilst, as a natural consequence, the prevailing uniformity of the physical conditions must inevitably engender a corresponding uniformity and simultaneousness in the development, growth, and final death and decay of the various lower forms of life that are under its inflnence. If this be true, we might expect that over large areas of the calcareous sea-bed a very preponderating number of the sponges would, almost simultaneously, spring into existence from the germs or gemmules left by a preceding generation, and as simultaneously multiply and die, to be succeeded in turn by another generation, and so on. We are thus furnished with an auxiliary, though (as I shall presently show) by no means the most important, factor in determining the simultaneous production of the flint nodules and sheets over extended horizontal areas."

"The stratification of the flints is due to the fact, already touched upon in a previous page, that nearly the whole of the silex derived from the Sponges on the one hand, and the continual subsidence of minute dead siliceous organisms on the other, is retained in the general protoplasmic layer, which

I have shown maintains its position on the immediate surface of the calcareous deposit, and gradually dissolves the silex. This layer, in virtue of its inferior specific gravity, rises with every increase in the thickness of the deposit, until at last the supersaturation of the protoplasmic masses with silex takes place, and the first step towards the consolidation into flint is accomplished—the continuity of sponge-life, and of the various other forms which tenant the calcareous areas, being secured through the oozy spaces which separate the sponge-beds, and thus admit of both adult and larval forms having free access to the overlying stratum of water.

"That the predisposition of silica, itself in reality a colloid, to form colloidal combinations with albuminous and other materials was known long before deep-sea exploration was dreamt of, is a well-known historical fact; it has been alluded to by most of the writers who have attempted an explanation of the mode of formation of the flints. But the various conditions that present themselves, from the earliest elimination of the silica from the sea-water to the period when it becomes finally consolidated, have never, that I am aware, been consecutively followed out.

"But that the colloidal *idiosyncrasy* of silica performed a much more important function in the phenomena connected with the flints than has heretofore been supposed, appears to me to be indicated by the evidence of the almost perfect incorporation of the organic silica with a colloid material, the unique *Amœbiform* nodulation of the flints, and its homogeneousness, whether occurring in nodules, in continuous sheets parallel to the stratification, or as sluggish overflows into fissures in the Chalk. But for a very highly developed colloidal condition of the materials, these peculiarities could not, I conceive, have presented themselves so uniformly throughout the formation. From a mere aqueous solution the deposit of silica would have exhibited totally different characters: there would have been a general infiltration into the substance of the chalk, the particles of which would thereby have been cemented together, so as to form a siliceous limestone; the various minute organic forms in which the silica showed itself, though, no doubt, capable of solution to a limited extent in water charged more or less highly with carbonic acid, and aided perhaps by the stupendous pressure, would have occasionally left more pronounced traces of their original structure than is observable in the body of the flints; probably all the fossils would have been either infiltrated with silica, or a substitution of that substance would have taken place even more frequently than we find it; there would have been no signs of the specific contractility pertaining to colloidal silicic acid; the resulting siliceous mineral, instead of appearing, when not rendered cherty by insoluble matter, as '*a colloidal glassy hyalite*,' would have presented itself either as compact quartz, or possibly as an alkaline silicate; and, lastly, there would have been wanting the evidence of the greater portion of the siliceous material having been, as it were, continuously waylaid and absorbed, as it descended from the surface of the ocean, into the colloidal protoplasmic mass resting upon the immediate upper surface of the calcareous deposit.

"In conclusion, I beg to express a hope that, although the length already attained by the present communication has debarred me from bringing forward a number of important facts and observations which would have materially strengthened my arguments, considering the complex nature of the inquiry and the special difficulties belonging to it, the following conclusions have, on the whole, been fairly sustained:—1. That the silica of the flints is derived mainly from the sponge-beds and sponge-fields which exist in immense profusion over the areas occupied by the Globigerine or calcareous 'ooze.' 2. That the deep-sea sponges, with their environment of protoplasmic matter, constitute by far the most important and essential factors in the production and stratification of the flints. 3. That, whereas nearly the whole of the carbonate of lime, derived partly from Foraminifera and other organisms that have lived and died at the bottom, and partly from such as have subsided to the bottom only after death, goes to build up the calcareous stratum, nearly the whole of the silica, whether derived from the deep-sea sponges or from surface Protozoa, goes to form the flints. 4. That the sponges are the only really important contributors to the flint-formation that live and die at the sea-bed. 5. That the flints are just as much an organic product as the Chalk itself. 6. That the stratification of the flint is the immediate result of all sessile Protozoan life being confined to the superficial layer of the muddy deposits. 7. That the substance which received the name of '*Bathybius*,' and was declared to be an independent living Moneron, is, in reality, sponge-protoplasm. 8. That no valid *lithological* distinction exists between the Chalk and the calcareous mud of the Atlantic; and *pro tanto*, therefore, the calcareous mud may be, and in all probability is, 'a continuation of *the* Chalk formation.'"

The history of *Bathybius* is too well known to the scientific world to need resuscitation in this place. Suffice it, therefore, to say that Sir Wyville Thomson and Dr. Carpenter found what they conceived to be vast masses of it in dredging in the North Atlantic, at the same time that they discovered vast numbers of vitreous sponges whose root-fibres and spicules were densely mixed up with it "like hairs in mortar." The deep-sea explorations on board the 'Challenger' confirmed the existence over other areas of the ocean besides the North Atlantic, where they had first been found, of like vast accumulations of sponges. On this all but conclusive evidence I ventured to assume that *Bathybius*, though not an independent living thing, was not altogether a myth, but veritable sponge-protoplasm. I refer to the circumstance now solely in explanation of my having appended to this paper a figure (Pl. XI. fig. 5) of the so-called *Bathybius* (copied from Häckel's figure, a representation of which is to be found in Sir W. Thomson's 'Depths of the Sea,' p. 412), with a view to show what I mean by an *amœbiform outline*. It must be recollected, however, that, owing to the nature of the conditions to which a little viscid mass of the kind has unavoidably to be subjected when examined in the microscope, an undue amount of flattening-out must take place. It had evidently taken place in the specimen from which Haeckel's drawing was taken. Hence, as a perfectly typical specimen of an *Amœba*-like form, it might certainly be surpassed. But it has this extraordinary merit—that it is *not* a figure of *Amœba*, but, according to my interpretation, *of sponge-protoplasm itself*, which, for the purposes of the present inquiry, is infinitely more to the purpose than the best figure of an *Amœba* could possibly have been. At all events any one looking at it who is also familiar with the appearances exhibited by *Amœba* will, at a glance, recognize the identity in character, and have no difficulty in perceiving that, but for the abnormal flattening-out of the mass by compression just referred to, no more conclusive testimony could have been furnished of the tendency of an organic colloid, and notably of the material itself which is so largely concerned, according to my hypothesis, in the production and determination of the unique but nevertheless undefinable type of irregular form of the flint nodules, to assume the forms in question.

I would add that I have never said or written, because I have never so believed, that the *living* sponge-protoplasm has any thing to do with the flint-formation. It stands in the same direct relation to the living parent sponges as the protoplasmic investment of a group of Botryllidæ, adherent to a mass of rock, does to these organisms; or the gelatinous thallus, often of great comparative bulk, which surrounds some of the freshwater protophytes. It is only after the death of the sponge that the spicules, already resting within the protoplasmic mass, combine with it and pass through the phase which has already been described by me in a previous portion of this paper, and was pointed out at p. 72 of my former paper in the extract which will be found *antè*, p. 192. It only remains for me to mention that the "Coccoliths" which form so prominent a feature in Häckel's figure have, in reality, no connexion whatever with the protoplasmic mass in which they rest. This I maintained in a paper on the nature of the so-called "*Bathybius*" (Ann. & Mag. Nat. Hist., Nov. 1875, p. 325). No doubt Coccoliths, subsiding in the shape of *disjecta membra* of the parent Coccospheres from the surface-waters of the ocean which they inhabit, are constantly showered down in certain regions upon the sponge-fields on the sea-bed below. And when this is the case they no doubt ultimately undergo silicification by replacement, just as the Foraminifera do. But in all probability their extremely minute size and delicate structure, when so silicified, alone prevent us from detecting their spectral pseudomorphs in the flints, except when silicified outside, or, I should rather say, not imbedded directly within the substance, but within a cavity of the siliceous jelly. It is in this wise that they remain perfect in the flint-cavities along with the also free Foraminifera and other included objects.

Having stated, in a former part of these observations (p. 193), that the strict limitation of all sessile animal life present at the sea-bed to the immediate surface-layer of the muddy deposit, which is an invariable characteristic of the calcareous and probably all abyssal areas where living Protozoa are to be found, supplies the key to the whole of the unique phenomena observable in the flint formation, I will now endeavour to furnish an ideal picture of the condition under which the periodical formation of the strata of flint takes place. The Potstones of the Norwich Chalk appear to me to furnish a supplementary clue to the solution of this problem in spite of the still undetermined question whether they are the fossil remains of some Titanic sponge, like the Ventriculites. Fortunately it is sufficient to know that they were gigantic vitreous sponges, and must have grown one after another, each out of the inverted bosom of its immediate predecessor and parent. In this manner, and in this manner only, does it seem possible to explain their forming columnar assemblages, the height of each column, as seen in such faces of the chalk as are exposed to view, approaching 30 feet, each individual in each columnar series being about 3 feet in height. Hence they traverse several successive strata of chalk, passing directly through the interstratified flint-layers, and showing neither symptoms of exhaustion nor diminution of size at any part of their upward range.

The inference I would draw from these facts is that, whereas the living portion of each individual sponge was restricted to one plane, and that plane was determined by, and therefore followed, each rise in the level of the surrounding deposit, the growth being due to simple repetitive divisions of parts, and not to a process of reproduction, until the maximum height and perhaps maximum age attainable by each individual had been arrived at, the death of the parent Titan was synchronous with and perhaps dependent on the intervention of a true reproductive process, whereby a successor was produced, who was destined to pass through a similar cycle of existence. We may assume also that the enormous size of each individual, as compared with the other sponges and forms of animal life that passed their lives on the same sea-bed, would enable it to rear its head high enough above the general level, when occasion demanded, to enable it to continue its existence uninterruptedly while the organisms around were perishing.

The *stratification* of the flints in layers of nodules and tabular masses may, I conceive, be similarly accounted for. Starting with the facts that the calcareous areas of the ocean (which are the representatives of those in which the ancient chalk was deposited) consist of vast expanses of this deposit, interrupted only by sponge-fields and sponge-beds (the one living and flourishing in the intervals from which it had either gradually expelled or yielded up its ground to the other), what must have occurred, and be still occurring, over the calcareous sea-bed? As the sponges encroached (in virtue of their undoubtedly more rapid growth *) on the domains of the Foraminifera, the latter would, here and there, be overwhelmed by the protoplasmic masses and simply asphyxiated. The sponges would, in turn, encroach on each other,

* Prof. Martin Duncan says, with reference to the slow rate at which deep-sea deposits are formed :—" With reference to the great thickness of deep-sea deposits, I have satisfied myself, from late researches, that the rate of deposition is exceedingly slow. Thus an electric cable was laid down in the *Globigerina*-ooze region; and six years after a considerable coral-growth had taken place on it. Some of the living calices were close above the cables; and therefore the deposit had been infinitesimal in that time. Again, there are slow-growing Echinoderms, Corals, and Spongida in place in many chalk series; and it is evident that the foraminiferal and sedimentary deposit was infinitely slower than their growth" (Anniversary Address Geol. Soc. London, 1877, by Prof. Martin Duncan, M.B., F.R.S., p. 44).

and eventually crush out and destroy some of their own kind—their siliceous remains, no longer restrained by vital forces, thenceforward becoming subject to material forces, and, as suggested in a previous portion of this paper, entering into colloidal combination with the protoplasm by which they were surrounded. Meanwhile Foraminiferal life would continue to multiply in all the vacant spaces. Small patches and masses of the ooze would be enveloped by masses of protoplasm; living organisms of various kinds would be similarly entrapped and entombed by the closing around and over them of the protoplasmic masses; and meanwhile a never-ceasing rain of minute calcareous- and siliceous-shelled organisms from the surface of the ocean would fall down upon the sea-bed, the protoplasmic and colloidal aggregations receiving their share, and allowing these foreign bodies to sink into their substance and become the bases of the future pseudomorphs of the flint.

But whilst the Foraminifera, as they died off, would leave their remains on the spots where they died, and thus assist infinitesimally, but continuously, in building up the cretaceous deposit, each new brood being born, living, and dying on the surface of the sea-bed, and the races being kept up by those occupying the vacant spaces, the sponges as they died off would not leave their remains on the sea-bed itself, but those remains would be one after the other absorbed by and form part of the colloidal masses of protoplasm and silica clinging together, and floating, as it were, on the immediate surface of the sea-bed. This tendency of the colloidal masses of silica "to adhere, aggregate, and contract," their viscidity, immiscibility with the water, and the extreme difficulty with which they could be made to sink at all into the substance of the ooze, would enable them continuously to maintain a position immediately resting upon the subjacent deposit; and in this wise they would accumulate, and, by perpetual accessions of siliceous remains from without, gradually become saturated with silica.

But even yet certain conditions would have to be fulfilled before any thing like simultaneous molecular or chemical action could take place over vast areas so as to produce the stratification of the resultant siliceous masses.

Owing to the perfect stillness prevailing at the sea-bed, the total absence of currents, the nearly constant uniformity of temperature, and the perfect uniformity and constancy of all the other conditions prevailing there, together with the immense periods concerned in the deposition of the strata, there is every probability that the growth of the entire series of sponges occupying the area in which they flourish in the highest degree, owing to the uniformity of all the above conditions, would proceed *pari passu.* It would follow, therefore, as a natural consequence, that the time requisite for the growth and arrival at maturity of the whole series would, in like manner, become uniform. The uniformity, moreover, of the supply of food, inseparable from the nature of the case—nay, the physical necessity that in a vast fluid medium like the ocean diffusion would take place with unerring uniformity of all the inorganic and organic substances on which nutrition depends—would assist, if not actually enforce, a rate of growth uniform in the groups distributed over the same areas. And thus the various groups would necessarily arrive simultaneously at that stage of their being when their asphyxiation by the supercharging of their protoplasmic masses with silica would end their career.

If we reflect, moreover, that we are dealing with conditions that must have been equally real and effective ever since the period when the earliest flint-producing deposits began to be formed at all, we can hardly doubt that the law which governs the growth of the sponges at the bottom of the deep sea must have caused them to complete their first cycle in the history of the flint-bearing chalk within a certain cosmic period, and that, owing to the uniformity of the conditions which have ever since prevailed, there must have been an approximate uniformity in the completion of each cycle since that period.

As the result of these operations, extensive areas of the calcareous sea-bed would, after a certain period, be simultaneously covered with protoplasm supersaturated with silica in its gelatinous condition, and a constant coalescence and tearing asunder of portions of the masses would take place, owing partly to their inherent contractility and diminution in volume through the expulsion of their combined water. Judging from what is known of the time necessary to bring about the change in silica from the gelatinous to the nearly perfectly anhydrous state, when it may be said to become finally consolidated into a hard, stony mass, it is not improbable that the process would not be a very protracted one, even when conducted on the vast scale referred to—a fact, if it be one, which would materially decrease the possibility of the extinction of the minute forms of life that build up the calcareous deposits. They would perpetuate their species in the intervals unoccupied by the nascent flint-masses, and gradually entomb them. On the other hand, the sponges would perpetuate their species by gemmules distributed over the general surface of the sea-bed, which would settle and develop wherever there were vacant areas and favourable conditions. In those tracts where the sponge-fields were altogether predominant, the dense colloidal areas, viscid and coherent enough to prevent their flowing out laterally, would become consolidated into tabular sheets, more or less unbroken, inasmuch as their contractility would exert itself chiefly in decreasing their thickness, as the expulsion of the combined water would go on uninterruptedly over their entire surfaces. On the other hand, in those tracts in which Sponge and Foraminiferal life had been split up into small contiguous patches, or the sponges occupied only sparsely scattered plots, the nodular flints would form, and be correspondingly distributed through the calcareous bed. It is here that the powerful contractile power resident in the colloidal masses would exert itself most freely on all sides, every little irregularity of surface caused by living or dead animal structures &c. tending still further to break up the masses, which, during their tearing asunder, would assume the *amœbiform* outlines which have been so often referred to by me as specially characteristic of animal protoplasm or albumen, and which may, to a certain extent, be seen when fresh albumen is mixed with cold water and gently shaken up, and then allowed to settle. That protoplasm—*the* protoplasm of the deep-sea sponges—does veritably assume these forms is an indisputable fact, attested by Häckel and Sir Wyville Thomson. I had myself once seen this material off the south-east coast of Greenland, in a sounding taken at a depth of nearly a couple of thousand fathoms, in which I found the minute sponge which Mr. Perceval Wright named after me. But I had not any idea at the time, or until many years afterwards, what the extraordinary glairy substance pervading the mud really was; and consequently I threw away the only chance I have had of seeing it in its perfectly recent stage.

It is a remarkable circumstance that, throughout the long cruise of the 'Challenger,' nothing whatever should have been discovered which might throw some light on the formation of the flints at the sea-bottom. Constant mention has been made of the immense abundance, in certain regions, of sponges; but I am not aware that any dead shell of a mollusk or echinoderm was found in the dredgings, the interior of which was filled up with colloid silica, or silica in an already consolidated state. One would have thought that, amongst the almost countless number of shells landed on the deck of the ship, whether from calcareous or siliceous bottoms, some trace of incipient fossilization or flint-formation must have turned up. But, on carefully considering the matter, it becomes obvious that the chances are a million to one, comparing human with cosmical periods, against the 'Challenger' dredge coming across any portion of the ocean in which that special stage in the flint-formation had been reached, when the consolidation of the pectous silica was just commencing, or just being completed. In all such operations of nature, we are too apt to forget that, whilst time and money are said to be almost convertible terms in human affairs, both time and money are unknown at the bottom of the sea, except when man has been either foolish or unfortunate enough to leave there all that remains to him of these good things.

EXPLANATION OF PLATE XI.

Figures 1 to 4 are diagrammatic representations of nodular masses of black flint from the Upper or White Chalk (as seen in section), and are intended to illustrate the mode of formation of the flint, its outer investing layer of chert, and other points referred to below.

Fig. 1 represents the section of a spherical nodule of solid black flint enveloped in its white or greyish-coloured outer layer of chert.

Fig. 2 represents the section of a similar spherical nodule, in which the central portion of a mass of calcareous and possibly some siliceous débris had been surrounded by the colloidal mass of protoplasm and silica, the contraction of which upon itself had been so great as to compress into a closely compacted mass the contained materials, these having been converted into chert by the incomplete replacement of their carbonate of lime by silica.

Fig. 3. A similar section to the last, in which, however, the included material was insufficient to occupy the whole cavity, the vacant portions having in all probability been occupied originally by water.

Fig. 4. A similar section to no. 2, having in the middle of its central cherty mass a drusy cavity lined with crystals of pure quartz.

Fig. 5 is a facsimile of the figure given by Sir Wyville Thomson (at p. 412 of his 'Depths of the Sea') of "*Bathybius*," as taken from Prof. Häckel's original drawing of a specimen examined by him under the microscope, in a supposed living condition. This figure is introduced here, not because I have ever believed in the existence of *Bathybius* as an independent structure, but because I regard the substance to which that name was given as simple sponge-protoplasm, in order to show that even in the dead state of this substance it is capable of exhibiting *amœbiform* outlines when subjected to gentle pressure.

BIBLIOGRAPHICAL NOTICE.

A Monograph of the Silurian Fossils of the Girvan District in Ayrshire. By H. A. Nicholson, M.D. &c., and R. Etheridge, Jun., Esq., F.G.S., &c. Fasciculus III. 8vo. London and Edinburgh: Blackwood & Son, 1880.

This part completes the first volume of a first-rate palæontological work, the result of enthusiastic labour on the part of the authors, who are fully conversant with their subject. Supplemental matter (derived mainly from new collections made in Ayrshire, and partly from further knowledge acquired in the progress of the work) forms a large part of this Fasciculus, namely the chapters on some of the fossil Protozoa, Cœlenterata (tabulate corals), and Crustacea, from Girvan. Some Annelidan remains, and several so-called "Worm-tracks," or trails and marks due to Crustaceans, Mollusks, and other animals besides Worms (as the authors now recognize them), are treated of; and various Echinoderms (Asteroidea and Crinoidea) are carefully described. These fossils are well illustrated in nine plates. The printing, paper, and plates are good. A careful index for the volume is appended; and altogether the authors may well be proud of their elegant and useful volume.

MISCELLANEOUS.

On the Existence of a Reptile of the Ophidian Type in the Beds with Ostrea columba, *of the Charente.* By M. H. E. Sauvage.

The Ophidian type, the maximum development of which is at the present epoch, seemed to make its first appearance at the base of the Tertiary, in the genera *Palæophis* and *Paleryx*, discovered by Owen in the London Clay. Fossil snakes, however, were known only by a few rare species found at Sheppey, in the phosphorites of Quercy, and in the Miocene of Sansan. Gervais had figured (but without giving it a name) the vertebra of an Ophidian derived from the sandstones which, at the island of Aix, are above the Cretaceous lignitiferous clays. M. Trémaux de Rochebrune, has since collected vertebræ which enable us to assert the presence of the serpent type as long ago as the Cenomanian epoch, in the Carentonian stage, the sands with *Ostrea columba* of the forest of Basseau in the Charente.

These vertebræ, which belong to the middle region of the body, are 0·013 metre high and 0·014 metre long, and indicate an animal of about 3 metres. The length is equal to the breadth at the level of the costal apophysis; so that the vertebra is strong and thickset. The articular condyle is supported by a very short neck; the articular cavity is circular, such as we find in the Boedonians. The neural canal is narrow, as in the Crotalians; and its section is triangular. The anterior face is broad, the diapophysis and zygosphene projecting but little. As in the Typhlopians, the parapophysis is reduced to a feeble tubercle, which joins with the diapophysis by a prominent line; the zygapophysis is inclined downwards, backwards, and inwards. The Boas and Pythons have the tubercle for the insertion of the rib placed very near the anterior margin of the centrum; this is also the case with the Cretaceous serpent. When we examine the vertebræ from above, the costal tubercle appears immediately outside of and a little behind the diapophysis, reminding us of what is seen in *Acrochordus*. The process of the neural spine is united to the diapophysis by a slightly excavated line. The neurapophysis is robust, and the neural spine broad, tolerably high, and flattened at its upper margin, which must have given attachment to a powerful ligament; this neural spine occupies the greater part of the length of the centrum, as in the Crotalians. The inferior surface of the centrum is flattened, which recalls the vertebra of the Amphisbænians; we may also recognize the absence of any hypapophysial tubercle, as in the Typhlopians, which, as is well known, form the passage from the Ophidians to the Saurians.

The Cretaceous serpent, at present the most ancient known Ophidian, presents such manifold analogies that it is not possible to refer it to one rather than another of the great divisions accepted for existing snakes; it indicates the existence as early as the Cenomanian epoch of a peculiar genus, which we propose to name *Simoliophis*, giving the species the denomination *S. Rochebruni*, from the name of the zealous naturalist to whom the discovery of this interesting type is due.—*Comptes Rendus*. Oct. 18, 1880, p. 671.

On some Arctic Holothurida.
By MM. D. C. Danielssen and J. Koren.

Among the Holothurida obtained by the Norwegian arctic expedition of 1878, the authors notice some new forms, and indicate certain points in the synonymy of previously described species. One of the former is described as the type of a new genus under the name of *Kolga hyalina*, the generic name being derived from that of one of the daughters of the goddess of the sea in the old northern mythology. The genus belongs to Théel's family Elpididæ, and is characterized as follows:—

Genus Kolga, g. n.

Body bilateral. A buccal disk, furnished with ten tentacles, turned towards the ventral surface. Anal aperture on the dorsal surface (near the posterior extremity). On the anterior part of the back a projecting collar, furnished with papillæ. Just in front of this (and usually concealed by it) are two apertures, one for the generative organs, the other for the stone-canal. Feet on both sides of the body and around its posterior extremity. Sexes separate. No intestinal appendages (lungs).

Kolga hyalina, sp. n.

Body 50 millims. long, 15–20 high, and 12–15 broad. Back very convex; on the collar six transversely arranged papillæ, of which the two middlemost are the longest. Sixteen long, thick, almost retractile feet, five on each side and six around the posterior end. Skin of the body diaphanous. Tentacles five-lobed, each lobe trifid.

Hab. Station 295, 71° 59′ N. lat., 11° 40′ E. long., at a depth of 1110 fathoms, temperature −1°·3 C., in *Biloculina*-ooze; Station 303, 75° 12′ N. lat., 3° 2′ E. long., at a depth of 1200 fathoms, temperature −1°·6 C., in brown mud. Feeds chiefly upon Diatoms and Foraminifera, swallowing the fine mud in which these creatures live in extraordinary abundance. The skin is transparent with a whitish tinge, so that in places where it is compressed it appears quite white. The five-lobed leaf of the tentacles, especially the part fringed with spicules, is deep orange-yellow. Buccal disk orange-yellow, with a darker, nearly brown ring round the mouth.

Myriotrochus Rinkii, Steenstrup*.

This species has been described under the same name by Lütken†, Stimpson‡, Selenka§, and Semper||; but Théel's *Myriotrochus Rinkii*, from Nova Zembla ¶, is regarded by MM. Koren and Danielssen as identical with *Chirodota brevis*, Huxley **, of which *Oligotrochus vitreus*, M. Sars††, is also a synonym.

Acanthotrochus, g. n.

Body cylindrical, apodal, rounded at the posterior extremity. Sexes separate; no intestinal appendages (organs of respiration). Skin furnished with two kinds of differently formed calcareous wheels. The one kind has winged radii, and teeth issuing from the inner margin of the periphery; the other kind of wheel is more than twice as large, and has also winged radii; but from the outer margin of the periphery there spring long teeth turned inwards. Twelve digitate tentacles, which can be concealed in the body.

Acanthotrochus mirabilis, sp. n.

Body 10–12 millims. long, cylindrical, widened and rounded off at the hinder extremity. Mouth and anal aperture central. Skin transparent, beset throughout with two different kinds of wheels. Those of one kind are stalked, small, furnished usually with eleven radii, and from the inner margin of the periphery spring generally two triangular teeth between each two radii. The larger wheels have usually 8–11 radii; and from the outer margin of the periphery spring long pointed teeth, equal in number to the radii. Twelve tentacles, furnished with three divided digitate leaves. Five longitudinal muscles. Skin in the living animal perfectly transparent, with fine glistening points, which under the lens are found to be calcareous wheels. The margins of the tentacles brownish.

Hab. Station 283, 73° 47′ N. lat., 14° 21′ E. long., in 767 fathoms, temperature −1°·4 C., *Biloculina*-ooze; Station 295 (see *Kolga hyalina*); Station 312, 74° 54′ N. lat., 14° 53′ E. long., in 658 fathoms, temperature −1°·2 C., brown and green mud.

* Vidensk. Meddel. naturh. Foren. Kjob. 1851, pp. 55–60.

† *Ibid.* 1857, p. 21.

‡ Synopsis Marine Invert. Arct. Exp., Proc. Acad. Nat. Sci. Phil. 1863, p. 138.

§ Zeitschr. f. wiss. Zool. xvii. (1867) p. 367.

|| Reisen im Archip. der Phil., Holothuria, i. p. 24 (1867).

¶ Appendix to Sutherland's 'Journal of a Voyage to Baffin's Bay,' &c., vol. ii. p. 221 (1852).

** Note sur quelques Holothuries des Mers de la Nouvelle Zemble (Upsal, 1877).

†† Vidensk. Selsk. Forhandl. 1865, p. 200, and in 'Fauna littoralis Norvegiæ,' Heft 3, p. 49.

Molpadia borealis, M. Sars, with which *M. violacea*, Studer, is probably identical, is referred by the authors to their genus *Trochostoma*, as also *Haplodactyla arctica*, Marenzeller. Allied to these is a new genus with two new species.

ANKYRODERMA, g. n.

Body cylindrical. Anterior end transversely cut off. Buccal disk furnished with fifteen tubular processes, alternating with fifteen oblong depressions, in which there are fifteen papilliform tentacles. The posterior extremity produced into a tail-like process. Cloacal aperture surrounded by five papillæ. Skin furnished with perforated papillæ, together with singular calcareous bodies consisting of five to six spatulate calcareous rods arranged in a stellate form, from the centre of which rises a calcareous anchor. No feet. Two intestinal appendages.

Ankyroderma Jeffreysii, sp. n.

Body elongated, cylindrical. Caudiform process long. Tentacles extremely small, furnished with three papillæ, of which the middle one is the largest. Genital papilla large, prominent. Calcareous bodies in the skin of three forms,—anchors attached to spatuliform calcareous rods, perforated calcareous plates with crowns, and oval claret-coloured bodies, placed in groups. The colour of the skin in the living animal is greenish with a violet tinge from the scattered red points, or sometimes dark violet. The anterior end of the body has a white pentagonal ring, within which is the white buccal disk with white tentacles. The genital papilla in part yellowish white, in part full yellow; caudiform prolongation white.

Hab. Station 260, Porsangerfjord in 127 fathoms, temperature 3°·5 C., and 261 Tanafjord in 127 fathoms, temperature 2°·8 C., on a muddy bottom; Station 262, Tanafjord in 148 fathoms, temperature 1°·9 C., ooze; Station 372, 97° 59′ N. lat., 5° 40′ E. long., in 459 fathoms, temperature −1° C., on bluish-grey mud.

Ankyroderma affine, sp. n.

Body cylindrical. The caudiform process shorter than in the preceding. Tentacles extremely small, with three papillæ. Genital papilla not prominent. On the surface of the skin tolerably regular rows of anchors attached to spatuliform calcareous rods. Among these are some peculiar calcareous branches, from the common starting-point (central point) of which there rises either a three-knobbed crown or a long calcareous spicule, or some exceedingly variously formed perforated calcareous plates with crowns; and in the deeper layer of the skin a great quantity of colourless more or less rounded bodies consisting of a conglomerate of calcareous prisms. Skin greenish; buccal disk and caudal point white.

Hab. Station 290, 72° 27′ N. lat., 20° 51′ E. long., in 191 fathoms, temperature 3°·5 C., sandy clay.

The genus *Trochostoma*, Dan. & Kor., includes *T. Thomsonii*, D. & K., with no cloaca; and with cloaca *T. boreale*, M. Sars, *T. arcticum*, Marenz., and *T.* (*Molp.*) *ooliticum*, Pourt.—*Nyt Magazin für Naturv.* Bd. xxv. pp. 83–140, pls. i.–vi.